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THE

POPULAR SCIENCE
MONTHLY.

DECEMBER, 1876.

FERMENTATION AND ITS BEARINGS ON THE PHENOMENA OF DISEASE.[1]

By JOHN TYNDALL, LL.D., F. R. S.

IN a book with which we are all familiar, amid other wise utterances, this one occurs: "Cast thy bread upon the waters; for thou shalt find it after many days." In more senses than one this precept is illustrated by my presence here to-night. Firstly, in a general sense, I stand indebted, morally and intellectually, to the poets, historians, and philosophers, of Scotland. Secondly, in a special sense, it so happens that one of the first rootlets of my scientific life derived its nutriment from this city of Glasgow. In early youth it was my ambition to qualify myself for the profession of a civil engineer, and as I grew up one of my aids toward the attainment of this object was the study of a periodical then published in Glasgow, and called *The Practical Mechanic's and Engineer's Magazine.* In that journal I read, with an interest unfelt before, a series of essays on various departments of science—on anatomy and physiology, on geology, on mechanics, on arithmetic, and on natural philosophy and chemistry. Biography and history were also included, while in detached articles various collateral subjects were discussed, such, for example, as the difference between Newton and Leibnitz as to the measure of moving force. It was there that I first learned what Leslie had done in Edinburgh, and what Davy had done in the Royal Institution. And I can now call to mind the day and hour when the yearning to possess such apparatus as Leslie and Davy possessed, and to institute with it such inquiries as they had instituted, rose to a kind of prophetic strength within me—prophetic, for it has come to pass that my own studies as a scientific man have been in great part pursued in that particular domain which had been enriched by the discoveries of Leslie; while the very instruments used by Davy, and which I first saw figured in the pages of the journal just mentioned, are the identical and familiar instruments with which my lectures in London are now illustrated.

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[1] A discourse delivered before the Glasgow Science Lectures Association, October 9, 1876.

Another point brought more or less home to me in those early days was the injury inflicted on the learner by bad scientific exposition. It does more than the negative damage of withholding instruction. It daunts the young mind, and saps the motive power of self-reliance. This I had experienced; and the essays referred to had this special value for me, that they not only instructed me, but gave me faith in my own capacity to be instructed. Since those days I have written books myself, and in doing so have tried to remember, and to act on the remembrance, that the labor spent in logically ordering one's thoughts, and in saying what one has to say clearly and correctly, is labor well bestowed.

The position assumed at the outset has, I think, been now made good. Glasgow in my case cast its bread upon the waters, and lo! it has returned after many days. Of the nutritive value of the return it is not for me to speak; for it may well have been soured by fortuitous ferments, mixed by the world's tainted atmosphere with the first pure leaven derived from the pages of *The Practical Mechanic's and Engineer's Magazine.*

The figure of speech here employed will become more intelligible as we proceed; for it is my desire and intention to spend the coming hour in speaking to you about *ferments*, not in a metaphorical, but in a real sense. Proper treatment is, I am persuaded, the only thing needed to make the subject both pleasant and profitable to you. For our knowledge of fermentation, and of the ground it covers, has augmented surprisingly of late, while every fresh accession to that knowledge strengthens the hope that its final issues will be of incalculable advantage to mankind.

One of the most remarkable characteristics of the age in which we live is its desire and tendency to connect itself organically with preceding ages—to ascertain how the state of things that now is came to be what it is. And the more earnestly and profoundly this problem is studied, the more clearly comes into view the vast and varied debt which the world of to-day owes to that fore-world in which man, by skill, valor, and well-directed strength, first replenished and subdued the earth. Our prehistoric fathers may have been savages, but they were clever and observant ones. They founded agriculture by the discovery and development of seeds whose origin is now unknown. They tamed and harnessed their animal antagonists, and sent them down to us as ministers, instead of rivals, in the fight for life. Later on, when the claims of luxury added themselves to those of necessity, we find the same spirit of invention at work. We have no historic account of the first brewer, but we glean from history that his art

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was practised, and its produce relished, more than two thousand years ago. Theophrastus, who was born nearly four hundred years before Christ, described beer as *the wine of barley.* It is extremely difficult to preserve beer in a hot country; still, Egypt was the land in which it was first brewed, the desire of man to quench his thirst with this exhilarating beverage overcoming all the obstacles which a hot climate threw in the way of its manufacture.

Our remote ancestors had also learned by experience that wine maketh glad the heart of man. Noah, we are informed, planted a vineyard, drank of the wine, and experienced the consequences. But, though wine and beer possess so old a history, a very few years ago no man knew the secret of their formation. Indeed, it might be said that until the present year no thorough and scientific account was ever given of the agencies which come into play in the manufacture of beer, of the conditions necessary to its health, and of the maladies and vicissitudes to which it is subject. Hitherto, indeed, the art and practice of the brewer have resembled those of the physician, both being founded on empirical observation. By this is meant the observation of facts apart from the principles which explain them, and which give the mind an intelligent mastery over them. The brewer learned from long experience the conditions, not the reasons, of success. But he had to contend, and he has still to contend, against unexplained perplexities. Over and over again his care has been rendered nugatory; his beer has fallen into acidity or rottenness, and disastrous losses have been sustained of which he has been unable to assign the cause. It is the hidden enemies against which the physician and the brewer have hitherto contended that recent researches are dragging into the light of day, thus preparing the way for their final extermination.

Let us glance for a moment at the outward and visible signs of fermentation. A few weeks ago I paid a visit to a private still in a Swiss chalet; and this is what I saw: In the peasant's bedroom was a cask with a very large bung-hole carefully closed. The cask contained cherries which had lain in it for fourteen days. It was not entirely filled with the fruit, an air-space being left above the cherries when they were put in. I had the bung removed, and a small lamp dipped into this space. Its flame was instantly extinguished. The oxygen of the air had entirely disappeared, its place being taken by carbonic-acid gas.[1] I tasted the cherries; they were very sour, though when put into the cask they were sweet. The cherries and the liquid associated with them were then placed in a copper boiler, to which a copper head was closely fitted. From the head proceeded a copper tube which passed straight through a vessel of cold water, and issued at the other side. Under the open end of the tube was placed a bottle to receive the spirit distilled. The flame of small wood-splinters being applied to the boiler, after a time vapor rose into the head, passed through the tube, was condensed by the cold of the water, and fell in a liquid fillet into the bottle. On being tasted, it proved to be that fiery and intoxicating spirit known in commerce as Kirsch or Kirschwasser.

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[1] The gas which is exhaled from the lungs after the oxygen of the air has done its duty in purifying the blood, the same also which effervesces from soda-water and champagne.

The cherries, it should be remembered, were here left to themselves, no ferment of any kind being added to them. In this respect what has been said of the cherry applies also to the grape. At the vintage the fruit of the vine is placed in proper vessels, and abandoned to its own action. It ferments, producing carbonic acid; its sweetness disappears, and at the end of a certain time the unintoxicating grape-juice is converted into intoxicating wine. Here, as in the case of the cherries, the fermentation is spontaneous—in what sense spontaneous will appear more clearly by-and-by.

It is needless for me to tell a Glasgow audience that the beer-brewer does not set to work in this way. In the first place the brewer deals not with the juice of fruits, but with the juice of barley. The barley having been steeped for a sufficient time in water, it is drained, and subjected to a temperature sufficient to cause the moist grain to germinate; after which, it is completely dried upon a kiln. It then receives the name of malt. The malt is crisp to the teeth, and decidedly sweeter to the taste than the original barley. It is ground, mashed up in warm water, then boiled with hops until all the soluble portions have been extracted; the infusion thus produced being called the *wort*. This is drawn off, and cooled as rapidly as possible; then, instead of abandoning the infusion, as the wine-maker does, to its own action, the brewer mixes yeast with his wort, and places it in vessels each with only one aperture open to the air. Soon after the addition of the yeast, a brownish froth, which is really new yeast, issues from the aperture, and falls like a cataract into troughs prepared to receive it. This frothing and foaming of the wort is a proof that the fermentation is active.

Whence comes the yeast which issues so copiously from the fermenting-tub? What is this yeast, and how did the brewer become in the first instance possessed of it? Examine its quantity before and after fermentation. The brewer introduces, say, 10 cwts. of yeast; he collects 40, or it may be 50 cwts. The yeast has, therefore, augmented from four to five fold during the fermentation. Shall we conclude that this additional yeast has been spontaneously generated by the wort? Are we not rather reminded of that seed which fell into good ground, and brought forth fruit, some thirty-fold, some sixty-fold, some a hundred-fold? On examination this notion of organic growth turns out to be more than a mere surmise. In the year 1680, when the microscope was still in its infancy, Leeuwenhoek turned the instrument upon this substance, and found it composed of minute globules suspended in a liquid. Thus knowledge rested until 1835, when Cagniard de la Tour in France, and Schwann in Germany, independently, but animated by a common thought, turned microscopes of improved definition and heightened powers upon yeast, and found it budding and sprouting before their eyes. The augmentation of the yeast alluded to above was thus proved to arise from the growth of a minute plant, now called *Torula* (or *Saccharomyces*) *cerevisiæ*. Spontaneous generation is therefore out of the question. The brewer deliberately sows the yeast-plant, which grows and multiplies in the wort as its proper soil. This discovery marks an epoch in the history of fermentation.

But where did the brewer find his yeast? The reply to this question is similar to that which must be given if the brewer were asked where he found his barley. He has received the seeds of both of them from preceding generations. Could we connect without solution of continuity the present with the past, we should probably be able to trace back the yeast employed by my friend Sir Fowell Buxton today to that employed by some Egyptian brewer two thousand years ago. But you may urge that there must have been a time when the first yeast-cell was generated. Granted—exactly as there was a time when the first barley-corn was generated. Let not the delusion lay hold of you, that a living thing is easily generated, because it is small. Both the yeast-plant and the barley-plant lose themselves in the dim twilight of antiquity, and in this our day there is no more proof of the spontaneous generation of the one than there is of the spontaneous generation of the other.

I stated a moment ago that the fermentation of grape-juice was spontaneous; but I was careful to add, "in what sense spontaneous will appear more clearly by-and-by." Now, this is the sense meant: The wine-maker does not, like the brewer and distiller, deliberately introduce either yeast, or any equivalent of yeast, into his vats; he does not consciously sow in them any plant, or the germ of any plant; indeed, he has been hitherto in ignorance whether plants or germs of any kind have had anything to do with his operations. Still, when the fermented grape-juice is examined, the living *Torula* concerned in alcoholic fermentation never fails to make its appearance. How is this? If no living germ has been introduced into the wine-vat, whence comes the life so invariably developed there?

You may be disposed to reply, with Turpin and others, that, in virtue of its own inherent powers, the grape-juice, when brought into contact with the vivifying atmospheric oxygen, runs spontaneously and of its own accord into these low forms of life. I have not the slightest objection to this explanation, provided proper evidence can be adduced in support of it. But the evidence adduced in its favor, as far as I am acquainted with it, snaps asunder under the least strain of scientific criticism. It is, as far as I can see, the evidence of men who, however keen and clever as *observers*, are not rigidly-trained *experimenters*. These alone are aware of the precautions necessary in investigations of this delicate kind. In reference, then, to the life of the wine-vat, what is the decision of experiment when carried out by competent men? Let a quantity of the clear, filtered "must" of the grape be boiled, so as to destroy such germs as it may have contracted from the air or otherwise. In contact with germless air the uncontaminated must never ferments. All the materials for spontaneous generation are there, but so long as there is no seed sown there is no life developed, and no sign of that fermentation which is the concomitant of life. Nor need you resort to a boiled liquid. The grape is sealed by its own skin against contamination from without. By an ingenious device, Pasteur has extracted from the interior of the grape its pure juice, and proved that in contact with pure air it never acquires the power to ferment itself, nor to produce fermentation in other liquids.[1] It is not, therefore, in the interior of the grape that the origin of the life observed in the vat is to be sought.

What, then, is its true origin? This is Pasteur's answer, which his well-proved accuracy renders worthy of all confidence: At the time of the vintage little microscopic particles are observed adherent, both to the outer surface of the grape and of the twigs which support the grape. Brush these particles into a capsule of pure water. It is rendered turbid by the dust. Examined by a microscope, these minute particles are seen to present the appearance of organized cells. Instead of receiving them in water, let them be brushed into the pure inert juice of the grape. Forty-eight hours after this is done, our familiar *Torula* is observed budding and sprouting, the growth of the plant being accompanied by all the other signs of active fermentation. What is the inference to be drawn from this experiment? Obviously that the particles adherent to the external surface of the grape are the veritable germs of that life which, after they have been sown in the juice, appears in such profusion. Wine is sometimes objected to on the ground that fermentation is "artificial;" but we notice here the responsibility of Nature. The ferment of the grape is in fact a parasite of the grape, and the art of the wine-maker from time immemorial has consisted in bringing—and it may be added, ignorantly bringing—two things thus closely associated by Nature into actual contact with each other. For thousands of years, what has been done consciously by the brewer has been done unconsciously by the wine-grower. The one has sown his leaven just as much as the other.

Nor is it necessary to impregnate the beer-wort with leaven to provoke fermentation. Abandoned to the contact of our common air, it sooner or later ferments; but the chances are, that the produce of that fermentation, instead of being agreeable, would be disgusting to the taste. By a rare accident we might get the true alcoholic fermentation, but the odds against obtaining it would be enormous. Pure air acting upon a lifeless liquid will never provoke fermentation; but our ordinary air is the vehicle of numberless germs which act as ferments when they fall into appropriate infusions. Some of them produce acidity, some putrefaction. The germs of our yeast-plant are also in the air; but so sparingly distributed that an infusion like beer-wort, exposed to the air, is almost sure to be taken possession of by foreign organisms. In fact, the maladies of beer are wholly due to the admixture of these objectionable ferments, whose forms and modes of nutrition differ materially from those of the true leaven of beer.

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[1] The liquids of the healthy animal body are also sealed from external contamination. Neither pure urine, collected fresh from the bladder, nor pure blood, drawn with due precautions from the veins, will ever putrefy in contact with pure air.

Working in an atmosphere charged with the germs of these organisms, you can understand how easy it is to fall into error in studying the action of any one of them. Indeed, it is only the most accomplished experimenter, who, moreover, avails himself of every means of checking his conclusions, that can walk without tripping through this land of pitfalls. Such a man is the French chemist Pasteur. He has taught us how to separate the commingled ferments of our air, and to study their pure individual action. Guided by him, let us fix our attention more particularly upon the growth and action of the true yeast-plant under different conditions. Let it be sown in a fermentable liquid, which is supplied with plenty of pure air. The plant will flourish in the aërated infusion, and produce large quantities of carbonic-acid gas—a compound, as you know, of carbon and oxygen. The oxygen thus consumed by the plant is the free oxygen of the air, which we suppose to be abundantly supplied to the liquid. The action is so far similar to the respiration of animals, which inspire oxygen and expire carbonic acid. If we examine the liquid even when the vigor of the plant has reached its maximum, we hardly find in it a trace of alcohol. The yeast has grown and flourished, but it has almost ceased to act as a ferment. And could every individual yeast-cell seize, without any impediment, free oxygen from the surrounding liquid, it is certain that it would cease to act as a ferment altogether.

What, then, are the conditions under which the yeast-plant must be placed so that it may display its characteristic quality? Reflection on the facts already referred to suggests a reply, and rigid experiment confirms the suggestion. Consider the Alpine cherries in their closed vessels. Consider the beer in its barrels, with a single small aperture open to the air, through which it is observed not to imbibe oxygen, but to pour forth carbonic acid. Whence come the volumes of oxygen necessary to the production of this latter gas? The small quantity of atmospheric air dissolved in the wort and overlying it would be totally incompetent to supply the necessary oxygen.

In no other way can the yeast-plant obtain the gas necessary for its respiration than by wrenching it from surrounding substances in which the oxygen exists, not free, but in a state of combination. It decomposes the sugar of the solution in which it grows, produces heat, breathes forth carbonic-acid gas, and one of the liquid products of the decomposition is our familiar alcohol. The act of fermentation, then, is a result of the effort of the little plant to maintain its respiration by means of combined oxygen, when its supply of free oxygen is cut off. As defined by Pasteur, fermentation is *life without air.*

But here the knowledge of that thorough investigator comes to our aid to warn us against errors which have been committed over and over again. It is not all yeast-cells that can thus live without air and provoke fermentation. They must be young cells which have caught their vegetative vigor from contact with free oxygen. But, once possessed of this vigor, the yeast may be transplanted into a saccharine infusion absolutely purged of air, where it will continue to live at the expense of the oxygen, carbon, and other constituents of the infusion. Under these new conditions its life, *as a plant*, will be by no means so vigorous as when it had a supply of free oxygen, but its action *as a ferment* will be indefinitely greater.

Does the yeast-plant stand alone in its power of provoking alcoholic fermentation? It would be singular if amid the multitude of low vegetable forms no other could be found capable of acting in a similar way. And here, again, we have occasion to marvel at that sagacity of observation among the ancients to which we owe so vast a debt. Not only did they discover the alcoholic ferment of yeast, but they had to exercise a wise selection in picking it out from others, and giving it special prominence. Place an old boot in a moist place, or expose common paste or a pot of jam to the air: it soon becomes coated with a blue-green mould, which is nothing else than the fructification of a little plant called *Penicillium glaucum.* Do not imagine that the mould has sprung spontaneously from boot, or paste, or jam; its germs, which are abundant in the air, have been sown, and have germinated, in as legal and legitimate a way as thistle-seeds wafted by the wind to a proper soil. Let the minute spores of *Penicillium* be sown in a fermentable liquid, which has been previously boiled in order to kill all other spores or seeds which it may contain; let pure air have free access to the mixture: the *Penicillium* will grow rapidly, striking long filaments into the liquid, and fructifying at its surface. Test the infusion at various stages of the plant's growth: you will never find in it a trace of alcohol. But forcibly submerge the little plant, push it down deep into the liquid, where the quantity of free oxygen that can reach it is insufficient for its needs: it immediately begins to act as a ferment, supplying itself with oxygen by the decomposition of the sugar, and producing alcohol as one of the results of the decomposition. Many other low microscopic plants act in a similar manner. In aërated liquids they flourish without any production of alcohol, but cut off from free oxygen they act as ferments, producing alcohol exactly as the real alcoholic leaven produces it, only less copiously. For all this knowledge we are indebted to Pasteur.

In the cases hitherto considered, the fermentation is proved to be the invariable correlative of *life*, being produced by organisms foreign to the fermentable substance. But the substance itself may also have within it, to some extent, the motive power of fermentation. The yeast-plant, as we have learned, is an assemblage of living cells; but so at bottom, as shown by Schleiden and Schwann, are all living organisms. Cherries, apples, peaches, pears, plums, and grapes, for example, are composed of cells, each of which is a living unit. And here I have to direct your attention to a point of extreme interest. In 1821, the celebrated French chemist, Bérard, established the important fact that all ripening fruit, exposed to the free atmosphere, absorbed the oxygen of the atmosphere, and liberated an approximately equal volume of carbonic acid. He also found that, when ripe fruits were placed in a confined atmosphere, the oxygen of the atmosphere was first absorbed, and an equal quantity of carbonic acid given out. But the process did not end here. After the oxygen had vanished, carbonic acid, in considerable quantities, continued to be expired by the fruits, which at the same time lost a portion of their sugar, becoming more acid to the taste, though the absolute quantity of acid was not augmented. This was an observation of capital importance, and Bérard had the sagacity to remark that the process might be regarded as a kind of fermentation.

Thus the living cells of fruits can absorb oxygen and breathe out carbonic acid, exactly like the living cells of the leaven of beer. Supposing the access of oxygen suddenly cut off, will the living fruit-cells as suddenly die, or will they continue to live as yeast lives, by extracting oxygen from the saccharine juices round them? This is a question of extreme theoretic significance. It was first answered affirmatively by the able and conclusive experiments of Lechartier and Bellamy, and the answer was subsequently confirmed and explained by the experiments and the reasoning of Pasteur. Bérard only showed the absorption of oxygen and the production of carbonic acid; Lechartier and Bellamy proved the production of alcohol, thus completing the evidence that it was a case of real fermentation. Influenced by his theoretic views, so full was Pasteur of the idea that the cells of a fruit would continue to live at the expense of the sugar of the fruit, that once in his laboratory, while conversing on these subjects with M. Dumas, he exclaimed, "I will wager that if a grape be plunged into an atmosphere of carbonic acid, it will produce alcohol and carbonic acid by the continued life of its own cells—that they will act for a time like the cells of the true alcoholic leaven." He made the experiment, and found the result to be what he had foreseen. He then extended the inquiry. Placing under a bell-jar twenty-four plums, he filled the jar with carbonic-acid gas; beside it he placed twenty-four similar plums uncovered. At the end of eight days he removed the plums from the jar, and compared them with the others. The difference was extraordinary. The uncovered fruits had become soft, watery, and very sweet; the others were firm and hard, their fleshy portions being not at all watery. They had, moreover, lost a considerable quantity of their sugar. They were afterward bruised, and the juice distilled. It yielded six and a half grammes of alcohol, or one per cent. of the total weight of the plums. Neither in these plums, nor in the grapes first experimented on by Pasteur, could any trace of the ordinary alcoholic leaven be found. The fermentation was the work of the living cells of the fruit itself, after air had been denied to them. When, moreover, the cells were destroyed by bruising, no fermentation ensued. The fermentation was the correlative of a vital act, and it ceased when life was extinguished.

Lüdersdorf was the first to show by this method that yeast acted, not, as Liebig had assumed, in virtue of its *organic*, but in virtue of its *organized*, character. He destroyed the cells of yeast by rubbing them on a ground-glass plate, and found that with the destruction of the organism, though its chemical constituents remained, the power to act as a ferment totally disappeared.

One word more in reference to Liebig may find a place here. To the philosophic chemist thoughtfully pondering these phenomena, familiar with the conception of molecular motion, and the changes produced by the interactions of purely chemical forces, nothing could be more natural than to see in the process of fermentation a simple illustration of molecular instability, the ferment propagating to surrounding molecular groups the overthrow of its own tottering combinations. Broadly considered, indeed, there is a certain amount of truth in this theory; but Liebig, who propounded it, missed the very kernel of the phenomena when he overlooked or contemned the part played in fermentation by microscopic life. He looked at the matter too little with the eye of the body, and too much with the spiritual eye. He practically neglected the microscope, and was unmoved by the knowledge which its revelations would have poured in upon his mind. His hypothesis, as I have said, was natural—nay, it was a striking illustration of Liebig's power to penetrate and unveil molecular actions; but it was an error, and as such has proved an *ignis fatuus* instead of a *pharos* to some of his followers.

I have said that our air is full of the germs of ferments differing from the alcoholic leaven, and sometimes seriously interfering with the latter. They are the weeds of this microscopic garden which often overshadow and choke the flowers. Let us take an illustrative case. Expose boiled milk to the air. It will cool, and then turn sour, separating like blood into clot and serum. Place a drop of this sour milk under a powerful microscope and watch it closely. You see the minute butter-globules animated by that curious quivering motion called the Brownian motion.[1] But let not this attract your attention too much, for it is another motion that we have now to seek. Here and there you observe a greater disturbance than ordinary among the globules; keep your eye upon the place of tumult, and you will probably see emerging from it a long, eel-like organism, tossing the globules aside and wriggling more or less rapidly across the field of the microscope. Familiar with one sample of this organism, which from its motions receives the name of vibrio, you soon detect numbers of them. It is these organisms which, by decomposing the milk, render it sour. This vibrio is in fact the butyric-acid ferment, as the yeast-plant is the alcoholic ferment. Keep the vibrio and its germs out of your milk and it will never turn sour. But, instead of becoming sour, milk may become putrid. This is due to the action of another living ferment. Examine your putrid milk microscopically, and you find it swarming with organisms much shorter than the vibrios, and manifesting sometimes a wonderful alacrity of motion. Keep this smaller organism and its germs out of your milk and it will never putrefy. Expose a mutton-chop to the air and keep it moist; in summer weather it soon stinks. Place a drop of the juice of the fetid chop under a powerful microscope; it is seen swarming with organisms resembling those in the putrid milk. These organisms, which receive the common name of bacteria,[2] are the agents of all putrefaction. Keep them and their germs from your meat and it will remain forever sweet. Thus we begin to see that within the world of life to which we ourselves belong there is another living world requiring the microscope for its discernment, but which, nevertheless, has the most important bearing on the welfare of the higher life-world.

And now let us reason together as regards the origin of these bacteria. A granular powder is placed in your hands, and you are asked to state what it is. You examine it, and have, or have not, reason to suspect that seeds of some kind are mixed up in it. But you prepare a bed in your garden, sow in it the powder, and soon after find a mixed crop of docks and thistles sprouting from your bed. Until this powder was sown neither docks nor thistles ever made their appearance in your garden. You repeat the experiment once, twice, ten times, fifty times. From fifty different beds after the sowing of the powder you obtain the same crop. What will be your response to the question proposed to you? "I am not in a condition," you would say, "to affirm that every grain of the powder is a dock-seed or a thistle-seed; but I am in a condition to affirm that both dock and thistle seeds form, at all events, part of the powder." Supposing a succession of such powders to be placed in your hands with grains becoming gradually smaller, until they dwindle to the size of impalpable dust-particles; assuming that you treat them all in the same way, and that from every one of them in a few days you obtain a definite crop—it may be clover, it may be mustard, it may be mignonette, it may be a plant more minute than any of these—the smallness of the particles, or of the plants that spring from them, does not affect the validity of the conclusion. Without a shadow of misgiving you would conclude that the powder must have contained the seeds or germs of the life observed. There is not in the range of physical science an experiment more conclusive nor an inference safer than this one.

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[1] Which I am inclined to regard as an effect of surface tension.

[2] Doubtless organisms exhibiting grave specific differences are grouped together under this common name.

Supposing the powder to be light enough to float in the air, and that you are enabled to see it there just as plainly as you saw the heavier powder in the palm of your hand. If the dust sown by the air instead of by the hand produce a definite living crop, with the same logical rigor you would conclude that the germs of this crop must be mixed with the dust. To take an illustration: The spores of the little plant *Penicillium glaucum*, to which I have already referred, are light enough to float in the air. A cut apple, a pear, a tomato, a slice of vegetable marrow, or, as already mentioned, an old moist boot, a dish of paste, or a pot of jam, constitutes a proper soil for the *Penicillium*. Now, if it could be proved that the dust of the air when sown in this soil produces this plant, while, wanting the dust, neither the air nor the soil, nor both together, can produce it, it would be obviously just as certain in this case that the floating dust contains the germs of *Penicillium* as that the powders sown in your garden contained the germs of the plants which sprung from them.

But how is the floating dust to be rendered visible? In this way: Build a little chamber and provide it with a door, windows, and window-shutters. Let an aperture be made in one of the shutters through which a sunbeam can pass. Close the door and windows, so that no light shall enter save through the hole in the shutter. The track of the sunbeam is at first perfectly plain and vivid in the air of the room. If all disturbance of the air of the chamber be avoided, the luminous track will become fainter and fainter, until at last it disappears absolutely, and no trace of the beam is to be seen. What rendered the beam visible at first? The floating dust of the air, which, thus illuminated and observed, is as palpable to sense as any dust or powder placed on the palm of the hand. In the still air the dust gradually sinks to the floor, or sticks to the walls or ceiling, until, finally, by this self-cleansing process, the air is entirely freed from mechanically suspended matter.

Thus far, I think, we have made our footing sure. Let us proceed. Chop up a beefsteak and allow it to remain for two or three hours just covered with warm water; you thus extract the juice of the beef in a concentrated form. By properly boiling the liquid and filtering it you can obtain from it a perfectly transparent beef-tea. Expose a number of vessels containing this tea to the moteless air of your chamber, and expose a number of similar vessels containing precisely the same liquid to the dust-laden air. In three days every one of the latter stinks, and, examined with the microscope, every one of them is found swarming with the bacteria of putrefaction. After three months, or three years, the beef-tea within the chamber is found in every case as sweet and clear, and as free from bacteria, as it was at the moment when it was first put in. There is absolutely no difference between the air within and that without, save that the one is dustless and the other dust-laden. Clinch the experiment thus: Open the door of your chamber and allow the dust to enter it. In three days afterward you have every vessel within the chamber swarming with bacteria, and in a state of active putrefaction. Here, also, the inference is quite as certain as in the case of the powder sown in your garden. Multiply your proofs by building fifty chambers instead of one, and by employing every imaginable infusion of wild animals and tame; of flesh, fish, fowl, and viscera; of vegetables of the most various kinds. If, in all these cases, you find the dust infallibly producing its crop of bacteria, while neither the dustless air nor the nutritive infusion, nor both together, are ever able to produce this crop, your conclusion is simply irresistible that the dust of the air contains the germs of the crop which has appeared in your infusions. I repeat, there is no inference of experimental science more certain than this one. In the presence of such facts, to use the words of a paper lately published in the "Philosophical Transactions," it would be simply monstrous to affirm that these swarming crops of bacteria are spontaneously generated.

Is there, then, no experimental proof of spontaneous generation? I answer without hesitation, *none!* But to doubt the experimental proof of a fact, and to deny its possibility, are two different things, though some writers confuse matters by making them synonymous. In fact, this doctrine of spontaneous generation, in one form or another, falls in with the theoretic beliefs of some of the foremost workers of this age; but it is exactly these men who have the penetration to see, and the honesty to expose, the weakness of the evidence adduced in its support.

And here observe how these discoveries tally with the common practices of life. Heat kills the bacteria, cold numbs them. When my housekeeper has pheasants in charge which she wishes to keep sweet, but which threaten to give way, she partially cooks the birds, kills the infant bacteria, and thus postpones the evil day. By boiling her milk she also extends its period of sweetness. Some weeks ago, in the Alps, I made a few experiments on the influence of cold upon ants. Though the sun was strong, patches of snow still maintained themselves on the mountain-slopes. The ants were found in the warm grass and on the warm rocks adjacent. Transferred to the snow, the rapidity of their paralysis was surprising. In a few seconds a vigorous ant, after a few languid struggles, would wholly lose its power of locomotion, and lie practically dead upon the snow. Transferred to the warm rock it would revive, to be again smitten with death-like numbness when retransferred to the snow. What is true of the ant is specially true of our bacteria. Their active life is suspended by cold, and with it their power of producing or continuing putrefaction. This is the whole philosophy of the preservation of meat by cold. The fish-monger, for example, when he surrounds his very assailable wares by lumps of ice, stays the process of putrefaction by reducing to numbness and inaction the organisms which produce it, and in the absence of which his fish would continue sweet and sound. It is the astonishing activity into which these bacteria are pushed by warmth that renders a single summer's day sometimes so disastrous to the great butchers of London and Glasgow. The bodies of guides lost in the crevices of Alpine glaciers have come to the surface forty years after their interment without the flesh showing any sign of putrefaction. But the most astonishing case of this kind is that of the hairy elephant of Siberia which was found incased in ice. It had been buried for ages, but when laid bare its flesh was sweet, and for some time afforded copious nutriment to the wild beasts which fed upon it.

Beer is assailable by all the organisms here referred to, some of which produce acetic, some lactic, and some butyric acid, while yeast is open to attack from the bacteria of putrefaction. In relation to the particular beverage the brewer wishes to produce, these foreign ferments have been properly called *ferments of disease*. The cells of the true leaven are globules, usually somewhat elongated. The other organisms are more or less rod-like or eel-like in shape, some of them being beaded so as to resemble necklaces. Each of these organisms produces a fermentation and a flavor peculiar to itself. Keep them out of your beer and it remains forever unaltered. Never without them will your beer contract disease. But their germs are in the air, in the vessels employed in the brewery, even in the yeast used to impregnate the wort. Consciously or unconsciously, the whole art of the brewer is directed against them. His aim is to paralyze if he cannot annihilate them.

For beer, moreover, the question of temperature is one of supreme importance; indeed, the recognized influence of temperature is causing on the Continent of Europe a complete revolution in the manufacture of beer. When I was a student in Berlin, in 1851, there were certain places specially devoted to the sale of Bavarian beer, which was then making its way into public favor. The beer is prepared by what is called the process of *low fermentation;* the name being given partly because the yeast of this beer, instead of rising to the top and issuing through the bung-hole, falls to the bottom of the cask; but partly, also, because it is produced at a low temperature. The other and older process, called *high fermentation*, is far more handy, expeditious, and cheap. In high fermentation eight days suffice for the production of the beer; in low fermentation, ten, fifteen, even twenty days, are found necessary. Vast quantities of ice, moreover, are consumed in the process of low fermentation. In the single brewery of Dreher, of Vienna, 100,000,000 pounds of ice are consumed annually in cooling the wort and beer. Notwithstanding these obvious and weighty drawbacks, the low fermentation is rapidly displacing the high upon the Continent. Here are some statistics which show the number of breweries of both kinds existing in Bohemia in 1860, 1865, and 1870:

	1860.	1865.	1870.
High fermentation . .	281	81	18
Low fermentation . .	135	459	831

Thus in ten years the number of high-fermentation breweries fell from 281 to 18, while the number of low-fermentation breweries rose from 135 to 831. The sole reason for this vast change—a change which involves a greater expenditure of time, labor, and money—is the additional command which it gives the brewer over the fortuitous ferments of disease. These ferments, which, it is to be remembered, are living organisms, have their activity suspended by temperatures below 10° C., and as long as they are reduced to torpor the beer remains untainted either by acidity or putrefaction. The beer of low fermentation is brewed in winter, and kept in cool cellars; the brewer being thus enabled to dispose of it at his leisure, instead of forcing its consumption to avoid the loss involved in its alteration if kept too long. Hops, it may be remarked, act to some extent as an antiseptic to beer. The essential oil of the hop is bactericidal: hence the strong impregnation with hop-juice of all beer intended for exportation.

These low organisms, which one might be disposed to regard as the beginnings of life, were we not warned that the microscope, precious and perfect as it is, has no power to show us the real beginnings of life, are by no means purely useless or purely mischievous in the economy of Nature. They are only noxious when out of their proper place. They exercise a useful and valuable function as the burners and consumers of dead matter, animal and vegetable, reducing such matter, with a rapidity otherwise unattainable, to innocent carbonic acid and water. Furthermore, they are not all alike, and it is only restricted classes of them that are really dangerous to man. One difference in their habits is worthy of special reference here. Air, or rather the oxygen of the air, which is absolutely necessary to the support of the bacteria of putrefaction, is absolutely deadly to the vibrios which provoke the butyric-acid fermentation. This is most simply illustrated by the following beautiful observation of Pasteur: You know the way of looking at these small organisms through the microscope. A drop of the liquid containing them is placed upon glass, and on the drop is placed a circle of exceedingly thin glass; for, to magnify them sufficiently, it is necessary that the microscope should come very close to the organisms. Round the edge of the circular plate of glass the liquid is in contact with the air, and incessantly absorbs it, including the oxygen. Here, if the drop be charged with bacteria, we have a zone of very lively ones. But through this living zone, greedy of oxygen and appropriating it, the vivifying gas cannot penetrate to the centre of the film. In the middle, therefore, the bacteria die, while their peripheral colleagues continue active. If a bubble of air chance to be inclosed in the film, round it the bacteria will pirouette and wabble until its oxygen has been absorbed, after which all their motions cease. Precisely the reverse of all this occurs with the vibrios of butyric acid. In their case it is the peripheral organisms that are first killed, the central ones remaining vigorous while ringed by a zone of dead. Pasteur, moreover, filled two vessels with a liquid containing these vibrios: through one vessel he led air, and killed its vibrios in half an hour; through the other he led carbonic acid, and after three hours found the vibrios fully active. It was while observing these differences of deportment fifteen years ago that the thought of life without air, and its bearing upon the theory of fermentation, flashed upon the mind of this admirable investigator.

And here I am tempted to inquire how it is that during the last five or six years so many of the cultivated English and American public, including members of the medical profession and contributors to some of our most intellectual journals, could be so turned aside as they have been from the pure well-spring of scientific truth to be found in the writings of Pasteur? The reason I take to be, that, while against unsound logic a healthy mind can always defend itself, against unsound experiment without discipline it is defenseless. To judge of the soundness of scientific data, and to reason from data assumed to be sound, are two totally different things. The one deals with the raw material of fact, the other with the logical textures woven from that material. Now, the logical loom may go accurately through all its motions, while the woven fibres may be all rotten. It is this inability, through lack of education in experiment, to judge of the soundness of experimental work, which lies at the root of the defection from Pasteur.

I will cite an example of this mistake of judgment. Between the large-type articles and the reviews of the *Saturday Review* essays on various subjects are interpolated. On Alpine slopes and in the calm of summer evenings, while reading these brief essays, I have been many a time impressed, not only with their sparkling cleverness, but with their deep-searching wisdom and their wealth of spiritual experience. In this central region of the *Review* the question of spontaneous generation has been taken up and discussed. The writer is not a whit behind his colleagues in literary brilliancy and logical force. But, having no touchstone in his own experience to enable him to distinguish a good experiment from a bad one, he has committed, on the point of the gravest practical import, the influence of the powerful journal in which he writes to the support of error. It is only, I would repeat, by practice among facts that the intellect is prepared to judge of facts, and no mere logical acuteness or literary skill can atone for the want of this necessary education.

We now approach an aspect of this question which concerns us still more closely, and which will be best illustrated by an actual fact. A few years ago I was bathing in an Alpine stream, and, returning to my clothes from the cascade which had been my shower-bath, I slipped upon a block of granite, the sharp crystals of which stamped themselves into my naked shin. The wound was an awkward one, but, being in vigorous health at the time, I hoped for a speedy recovery. Dipping a clean pocket-handkerchief into the stream, I wrapped it round the wound, limped home, and remained for four or five days quietly in bed. There was no pain, and at the end of this time I thought myself quite fit to quit my room. The wound, when uncovered, was found perfectly clean, uninflamed, and entirely free from pus. Placing over it a bit of gold-beater's-skin, I walked about all day. Toward evening itching and heat were felt; a large accumulation of pus followed, and I was forced to go to bed again. The water-bandage was restored, but it was powerless to check the action now set up; arnica was applied, but it made matters worse. The inflammation increased alarmingly, until finally I was ignobly carried on men's shoulders down the mountain, and transported to Geneva, where, thanks to the kindness of friends, I was immediately placed in the best medical hands. On the morning after my arrival in Geneva, Dr. Gautier discovered an abscess in my instep, at a distance of five inches from the wound. The two were connected by a channel, or *sinus*, as it is technically called, through which he was able to empty the abscess without the application of the lance.

By what agency was that channel formed—what was it that thus tore asunder the sound tissue of my instep, and kept me for six weeks a prisoner in bed? In the very room where the water-dressing had been removed from my wound and the gold-beater's-skin applied to it, I opened this year a number of tubes, containing perfectly clear and sweet infusions of fish, flesh, and vegetable. These hermetically-sealed infusions had been exposed for weeks, both to the sun of the Alps and to the warmth of a kitchen, without showing the slightest turbidity or sign of life. But two days after they were opened the greater number of them swarmed with the bacteria of putrefaction, the germs of which had been contracted from the dust-laden air of the room. And, had the pus from my abscess been examined, my memory of its appearance leads me to infer that it would have been found equally swarming with these bacteria—that it was their germs which got into my incautiously-opened wound. They were the subtile workers that burrowed down my shin, dug the abscess in my instep, and produced effects which might well have proved fatal to me.

And here we come directly face to face with the labors of a man who has established for himself an imperishable reputation in relation to this subject, who combines the penetration of the true theorist with the skill and conscientiousness of the true experimenter, and whose practice is one continued demonstration of the theory that the putrefaction of wounds is to be averted by the destruction of the germs of bacteria. Not only from his own reports of his cases, but from the reports of eminent men who have visited his hospital, and from the opinions expressed to me by Continental surgeons, do I gather that one of the greatest steps ever made in the art of surgery was the introduction of the antiseptic system of treatment, practised first in Glasgow and now in Edinburgh, by Prof. Lister.

The interest of this subject does not slacken as we proceed. We began with the cherry-cask and beer-vat; we end with the body of man. There are persons born with the power of interpreting natural facts, as there are others smitten with everlasting incompetence in regard to such interpretation. To the former class in an eminent degree belonged the celebrated philosopher Robert Boyle, whose words in relation to this subject have in them the forecast of prophecy. "And let me add," writes Boyle in his "Essay on the Pathological Part of Physik," "that he that thoroughly understands the nature of ferments and fermentations shall probably be much better able than he that ignores them to give a fair account of divers phenomena of several diseases (as well fevers as others) which will perhaps be never properly understood without an insight into the doctrine of fermentations."

Two hundred years have passed since these pregnant words were written, and it is only in this our day that men are beginning to fully realize their truth. In the domain of surgery the justice of Boyle's surmise has been most strictly demonstrated. Demonstration is indeed the only word which fitly characterizes the evidence brought forward by Prof. Lister. You will grasp in a moment his leading idea. Take the extracted juice of beef or mutton, so prepared as to be perfectly transparent, and entirely free from the living germs of bacteria. Into the clear liquid let fall the tiniest drop of an infusion charged with the bacteria of putrefaction. Twenty-four hours subsequently the clear extract will be found muddy throughout, the turbidity being due to swarms of bacteria generated by the drop with which the infusion was inoculated. At the same time the infusion will have passed from a state of sweetness to a state of putridity. Let a drop similar to that which has produced this effect fall into an open wound: the juices of the living body nourish the bacteria as the beef or mutton juice nourished them, and you have putrefaction produced within the system. The air, as I have said, is laden with floating matter which, when it falls upon the wound, acts substantially like the drop. Prof. Lister's aim is to destroy the life of that floating matter—to kill such germs as it may contain. Had he, for example, dressed my wound, instead of opening it incautiously in the midst of air laden with the germs of bacteria, and instead of applying to it gold-beater's-skin, which probably carried these germs upon its surface, he would have showered upon the wound, during the time of dressing, the spray of some liquid capable of killing the germs. The liquid usually employed for this purpose is dilute carbolic acid, which, in his skilled hands, has become a specific against putrefaction and all its deadly consequences.

We now pass the bounds of surgery proper, and enter the domain of epidemic disease, including those fevers so sagaciously referred to by Boyle. The most striking analogy between a *contagium* and a ferment is to be found in the power of indefinite self-multiplication possessed and exercised by both. You know the exquisitely truthful figures regarding leaven employed in the New Testament. A particle hid in three measures of meal leavens it all. A little leaven leaveneth the whole lump. In a similar manner a particle of *contagium* spreads through the human body and may be so multiplied as to strike down whole populations. Consider the effect produced upon the system by a microscopic quantity of the virus of small-pox. That virus is to all intents and purposes a seed. It is sown as leaven is sown, it grows and multiplies as leaven grows and multiplies, and it always reproduces itself. To Pasteur we are indebted for a series of masterly researches, wherein he exposes the looseness and general baselessness of prevalent notions regarding the transmutation of one ferment into another. He guards himself against saying it is impossible. The true investigator is sparing in the use of this word, though the use of it is unsparingly ascribed to him; but, as a matter of fact, Pasteur has never been able to effect the alleged transmutation, while he has been always able to point out the open doorways through which the affirmers of such transmutations had allowed error to march in upon them.[1]

The great source of error here has been already alluded to in this discourse. The observers worked in an atmosphere charged with the germs of different organisms; the mere accident of first possession rendering now one organism, now another, triumphant. In different stages, moreover, of its fermentative or putrefactive changes, the same infusion may so alter as to be successively taken possession of by different organisms. Such cases have been adduced to show that the earlier organisms must have been transformed into the later ones, whereas they are simply cases in which different germs, because of changes in the infusion, render themselves valid at different times.

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[1] Those who wish for an illustration of the care necessary in these researches, and of the carelessness with which they have in some cases been conducted, will do well to consult the Rev. W. H. Dallinger's excellent "Notes on Heterogenesis," in the October number of the *Popular Science Review.*

By teaching us how to cultivate each ferment in its purity—in other words, by teaching us how to rear the individual organism apart from all others—Pasteur has enabled us to avoid all these errors. And where this isolation of a particular organism has been duly effected it grows and multiplies indefinitely, but no change of it into another organism is ever observed. In Pasteur's researches the Bacterium remained a Bacterium, the Vibrio a Vibrio, the Penicillium a Penicillium, and the Torula a Torula. Sow any of these in a state of purity in an appropriate liquid, you get it, and it alone, in the subsequent crop. In like manner, sow small-pox in the human body, your crop is small-pox. Sow there scarlatina, and your crop is scarlatina. Sow typhoid virus, your crop is typhoid—cholera, your crop is cholera. The disease bears as constant a relation to its contagium as the microscopic organisms just enumerated do to their germs, or indeed as a thistle does to its seed. No wonder, then, with analogies so obvious and so striking, that the conviction is spreading and growing daily in strength that reproductive parasitic life is at the root of epidemic disease—that living ferments finding lodgment in the body increase there and multiply, directly ruining the tissue on which they subsist, or destroying life indirectly by the generation of poisonous compounds within the body. This conclusion, which comes to us with a presumption almost amounting to demonstration, is clinched by the fact that virulently-infective diseases have been discovered with which living organisms are as closely and as indissolubly associated as the growth of Torula is with the fermentation of beer.

And here, if you will permit me, I would utter a word of warning to well-meaning people. We have now reached a phase of this question when it is of the very last importance that light should once for all be thrown upon the manner in which contagious and infectious diseases take root and spread. To this end the action of various ferments upon the organs and tissues of the living body must be studied; the habitat of each special organism concerned in the production of each specific disease must be determined, and the mode by which its germs are spread abroad as sources of further infection. It is only by such rigidly accurate inquiries that we can obtain final and complete mastery over these destroyers. Hence, while abhorring cruelty of all kinds, while shrinking sympathetically from all animal suffering—suffering which my own pursuits never call upon me to inflict—an unbiased survey of the field of research now opening out before the physiologist causes me to conclude that no greater calamity could befall the human race than the stoppage of experimental inquiry in this direction. A lady whose philanthropy has rendered her illustrious said to me, some time ago, that science was becoming immoral; that the researches of the past, unlike those of the present, were carried on without cruelty. I replied to her that the science of Kepler and Newton, to which she referred, dealt with the laws and phenomena of inorganic Nature; but that one great advance made by modern science was in the direction of biology, or the science of life; and that in this new direction scientific inquiry, though at the outset pursued at the cost of some temporary suffering, would in the end prove a thousand times more beneficent than it had ever hitherto been. I said this because I saw that the very researches which the lady deprecated were leading us to such a knowledge of epidemic diseases as will enable us finally to sweep these scourges of the human race from the face of this fair earth.

This is a point of such special importance that I should like to bring it home to your intelligence by a single trustworthy illustration. In 1850, two distinguished French observers, MM. Davainne and Rayer, noticed, in the blood of animals which had died of the virulent disease called *splenic fever*, small microscopic organisms resembling transparent rods, but neither of them at that time attached any significance to the observation. In 1861 Pasteur published a memoir on the fermentation of butyric acid, wherein he described the organism which provoked it; and, after reading this memoir, it occurred to Davainne that splenic fever might be a case of fermentation set up within the animal body by the organisms which had been observed by him and Rayer. This idea has been placed beyond all doubt by subsequent research.

Some years in advance of the labors undertaken by Davainne, observations of the highest importance had been made on splenic fever by Pollender and Brauell. Two years ago, Dr. Burdon-Sanderson gave us a very clear account of what was known up to that time of this disorder. With regard to the permanence of the contagium, it had been proved to hang for years about localities where it had once prevailed; and this seemed to show that the rod-like organisms could not constitute the contagium, because their infective power was found to vanish in a few weeks. But other facts established an intimate connection between the organisms and the disease, so that a review of all the facts caused Dr. Sanderson to conclude that the contagium existed in two distinct forms: the one "fugitive," and visible as transparent rods; the other permanent but "latent," and not yet brought within the grasp of the microscope.

At the time that Dr. Sanderson was writing this report, a young German physician, named Koch, occupied with the duties of his profession in an obscure country district, was already at work, applying, during his spare time, various original and ingenious devices to the investigation of splenic fever. He studied the habits of the rod-like organisms, and found the aqueous humor of an ox's eye to be particularly suitable for their nutrition. With a drop of the aqueous humor he mixed the tiniest speck of a liquid containing the rods, placed the drop under his microscope, warmed it suitably, and observed the subsequent action. During the first two hours hardly any change was noticeable; but at the end of this time the rods began to lengthen, and the action was so rapid that at the end of three or four hours they attained from ten to twenty times their original length. At the end of a few additional hours they had formed filaments in many cases a hundred times the length of the original rods. The same filament, in fact, was frequently observed to stretch through several fields of the microscope. Sometimes they lay in straight lines parallel to each other; in other cases they were bent, twisted, and coiled, into the most graceful figures; while sometimes they formed knots of such bewildering complexity that it was impossible for the eye to trace the individual filaments through the confusion.

Had the observation ended here an interesting scientific fact would have been added to our previous store, but the addition would have been of little practical value. Koch, however, continued to watch the filaments, and after a time noticed little dots appearing within them. These dots became more and more distinct, until finally the whole length of the organism was studded with minute ovoid bodies, which lay within the outer integument like peas within their shell. By-and-by the integument fell to pieces, the place of the organism being taken by a long row of seeds or spores. These observations, which were confirmed in all respects by the celebrated naturalist Cohn, of Breslau, are of the first importance. They clear up the existing perplexity regarding the latent and visible contagia of splenic fever; for, in the most conclusive manner, Koch proved the spores, as distinguished from the rods, to constitute the contagium of the fever in its most deadly and persistent form.

How did he reach this important result? Mark the answer. There was but one way open to him to test the activity of the contagium, and that was the inoculation with it of living animals. He operated upon Guinea-pigs and rabbits, but the vast majority of his experiments were made with mice. Inoculating them with the fresh blood of an animal suffering from splenic fever, they invariably died of the same disease within twenty or thirty hours after inoculation. He then sought to determine how the contagium maintained its vitality. Drying the infectious blood containing the rod-like organisms, in which, however, the spores were not developed, he found the contagium to be that which Dr. Sanderson calls "fugitive." It maintained its power of infection for five weeks at the farthest. He then dried blood containing the fully-developed spores, and exposed the substance to a variety of conditions. He permitted the dried blood to assume the form of dust; wetted this dust, allowed it to dry again, permitted it to remain for an indefinite time in the midst of putrefying matter, and subjected it to various other tests. After keeping the spore-charged blood which had been treated in this fashion for four years, he inoculated a number of mice with it, and found its action as fatal as that of blood fresh from the veins of an animal suffering from splenic fever. There was no single escape from death after inoculation by this deadly contagium. Uncounted millions of these spores are developed in the body of every animal which has died of splenic fever, and every spore of these millions is competent to produce the disease. The name of this formidable parasite is *Bacillus anthracis.*[1]

Now, the very first step toward the extirpation of these contagia is the knowledge of their nature; and the knowledge brought to us by Dr. Koch will render as certain the stamping out of splenic fever as the stoppage of the plague of *pébrine* by the researches of Pasteur. One small item of statistics will show what this implies. In the single district of Novgorod in Russia, between the years 1867 and 1870, over 56,000 cases of death by splenic fever, among horses, cows, and sheep, were recorded. But its ravages did not confine themselves to the animal world, for, during the time and in the district referred to, 528 human beings perished in the agonies of the same disease.

A description of the fever will help you to come to a right decision on the point which I wish to submit to your consideration. "An animal," says Dr. Burdon-Sanderson, "which perhaps for the previous day has declined food and shown signs of general disturbance, begins to shudder and to have twitches of the muscles of the back, and soon after becomes weak and listless. In the mean time the respiration becomes frequent and often difficult, and the temperature rises to three or four degrees above the normal; but soon convulsions, affecting chiefly the muscles of the back and loins, usher in the final collapse, of which the progress is marked by complete loss of power of moving the trunk or extremities, diminution of temperature, mucous and sanguinolent alvine evacuations, and similar discharges from the mouth and nose." In a single district of Russia, as above remarked, 56,000 horses, cows, and sheep, and 528 men and women, perished in this way during a period of two or three years. What the annual fatality is throughout Europe I have no means of knowing. Doubtless it must be very great. The question, then, which I wish to submit to your judgment is this: Is the knowledge which reveals to us the nature, and which assures the extirpation, of a disorder so virulent and so vile, worth the price paid for it? It is exceedingly important that assemblies like the present should see clearly the issues at stake in such questions as this, and that the properly-informed common-sense of the community should temper, if not restrain, the rashness of those who, meaning to be tender, would virtually enact the most hideous cruelty by the imposition of short-sighted restrictions upon physiological investigation. It is a modern instance of zeal for God, but not according to knowledge, and an instructed public opinion must correct its excess.

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[1] To produce its characteristic effects the contagium of splenic fever must enter the blood. The virulently-infective spleen of a diseased animal may be eaten with impunity by mice. On the other hand, the disease refuses to be communicated by inoculation to dogs, partridges, or sparrows. In their blood *Bacillus anthracis* ceases to act as a ferment.

And now let us cast a backward glance on the field we have traversed, and try to extract from our labors such further profit as they can yield. For more than two thousand years the attraction of light bodies by amber was the sum of human knowledge regarding electricity, and for more than two thousand years fermentation was effected without any knowledge of its cause. In science one discovery grows out of another, and cannot appear without its proper antecedent. Thus, before fermentation could be understood, the microscope had to be invented and brought to a considerable degree of perfection. Note the growth of knowledge. Leeuwenhoek, in 1680, found yeast to be a mass of floating globules, but he had no notion that the globules were alive. This was proved in 1835 by Cagniard de la Tour and Schwann. Then came the question as to the origin of such microscopic organisms, and in this connection the memoir of Pasteur, published in the "Annales de Chimie" for 1862, is epoch-making, proving as it did to all competent minds spontaneous generation to be thus far a chimera. On that investigation all Pasteur's subsequent labors were based. Ravages had over and over again occurred among French wines. There was no guarantee that they would not become acid or bitter, particularly when exported. The commerce in wines was thus restricted, and disastrous losses were often inflicted on the wine-grower. Every one of these diseases was traced to the life of an organism. Pasteur ascertained the temperature which killed these ferments of disease, proving it to be so low as to be perfectly harmless to the wine. By the simple expedient of heating the wine to a temperature of 50° centigrade, he rendered it unalterable, and thus saved his country the loss of millions. He then went on to vinegar—*vin aigre*, acid wine—which he proved to be produced by a fermentation set up by a little fungus called *Mycoderma aceti. Torula*, in fact, converts the grape-juice into alcohol, and *Mycoderma aceti* converts the alcohol into vinegar. Here also frequent failures occurred and severe losses were sustained. Through the operation of unknown causes, the vinegar often became unfit for use; sometimes, indeed, falling into utter putridity. It had been long known that mere exposure to the air was sufficient to destroy it. Pasteur studied all these changes, traced them to their living causes, and showed that the permanent health of the vinegar was insured by the destruction of this life. He passed from the diseases of vinegar to the study of a malady which a dozen years ago had all but ruined the silk-husbandry of France. This malady, which received the name of *pébrine*, was the product of a parasite which first took possession of the intestinal canal of the silkworm, spread throughout its body, and filled the sack which ought to contain the viscid matter of the silk. Thus smitten, the worm would go automatically through the process of spinning when it had nothing to spin. Pasteur followed this parasitic destroyer from year to year, and, led by his singular power of combining facts with the logic of facts, discovered eventually the precise phase in the development of the insect when the disease which assailed it could with certainty be stamped out. Pasteur's devotion to this inquiry cost him dear. He restored to France her silk-husbandry, rescued thousands of her population from ruin, set the looms of Italy also to work, but emerged from his labors with one of his sides permanently paralyzed. His last investigation is embodied in a work entitled "Studies on Beer," in which he describes a method of rendering beer permanently unchangeable. That method is not so simple as those found effectual with wine and vinegar, but the principles which it involves are sure to receive extensive application at some future day. Taking into account all these labors of Pasteur, it is no exaggeration to state that the money value of his work would go far to cover the indemnity which France had to pay to Germany.

There are other reflections connected with this subject which, even were I to pass them over without remark, would sooner or later occur to every thoughtful mind in this assembly. I have spoken of the floating dust of the air, of the means of rendering it visible, and of the perfect immunity from putrefaction which accompanies the contact of moteless air. Consider the woes which this wafted matter, during historic and prehistoric ages, has inflicted on mankind; consider the loss of life in hospitals from putrefying wounds; consider the loss in places where there are plenty of wounds but no hospitals, and in the ages before hospitals were anywhere founded; consider the slaughter which has hitherto followed that of the battle-field, when those bacterial destroyers are let loose, often producing a mortality far greater than that of the battle itself; add to this the other conception that in times of epidemic disease the self-same floating matter has frequently, if not always, mingled with it the special germs which produce the epidemic, being thus enabled to sow pestilence and death over nations and continents—consider all this, and you will come with me to the conclusion that all the havoc of war, ten times multiplied, would be evanescent if compared to the ravages due to atmospheric dust.

This preventable destruction is going on to-day, and it has been permitted to go on for ages, without a whisper of information regarding its cause being vouchsafed to the suffering sentient world. We have been scourged by invisible thongs, attacked from impenetrable ambuscades, and it is only to-day that the light of science is being let in upon the murderous dominion of our foes. Men of Glasgow, these facts excite in me the thought that the rule and governance of this universe are different from what we in our youth supposed them to be—that the inscrutable Power, at once terrible and beneficent, in whom we live and move and have our being and our end, is to be propitiated by means different from those usually resorted to. The first requisite toward such propitiation is *knowledge;* the second is *action*, shaped and illuminated by that knowledge. Of knowledge we already see the dawn, which will open out by-and-by to perfect day, while the action which is to follow has its unfailing source and stimulus in the moral and emotional nature of man—in his desire for personal well-being, in his sense of duty, in his compassionate sympathy with the sufferings of his fellow-men. "How often," says Dr. William Budd, in his celebrated work on "Typhoid Fever"—"how often have I seen in past days, in the single narrow chamber of the day-laborer's cottage, the father in the coffin, the mother in the sick-bed in muttering delirium, and nothing to relieve the desolation of the children but the devotion of some poor neighbor, who in too many cases paid the penalty of her kindness in becoming herself the victim of the same disorder!" From the vantage-ground already won I look forward with confident hope to the triumph of medical art over scenes of misery like that here described. The cause of the calamity being once clearly revealed, not only to the physician, but to the public, whose intelligent coöperation is absolutely essential to success, the final victory of humanity is only a question of time. We have already a foretaste of that victory in the triumphs of surgery as practised at your doors.

THE PROTECTION OF BUILDINGS FROM LIGHTNING.

By Professor J. CLERK MAXWELL.

MOST of those who have given directions for the construction of lightning-conductors have paid great attention to the upper and lower extremities of the conductor. They recommend that the upper extremity of the conductor should extend somewhat above the highest part of the building to be protected, and that it should terminate in a sharp point, and that the lower extremity should be carried as far as possible into the conducting strata of the ground, so as to "make" what telegraph engineers call "a good earth."

The electrical effect of such an arrangement is to *tap*, as it were, the gathering charge by facilitating a quiet discharge between the atmospheric accumulation and the earth. The erection of the conductor will cause a somewhat greater number of discharges to occur at the place than would have occurred if it had not been erected; but each of these discharges will be smaller than those which would have occurred without the conductor. It is probable, also, that fewer discharges will occur in the region surrounding the conductor.

It appears to me that these arrangements are calculated rather for the benefit of the surrounding country, and for the relief of clouds laboring under an accumulation of electricity, than for the protection of the building on which the conductor is erected.

What we really wish is, to prevent the possibility of an electric discharge taking place within a certain region, say in the inside of a gunpowder-manufactory. If this is clearly laid down as our object, the method of securing it is equally clear.

An electric discharge cannot occur between two bodies, unless the difference of their potentials is sufficiently great, compared with the distance between them. If, therefore, we can keep the potentials of all bodies within a certain region equal, or nearly equal, no discharge will take place between them. We may secure this by connecting all these bodies by means of good conductors, such as copper-wire ropes, but it is not necessary to do so, for it may be shown by experiment that, if every part of the surface surrounding a certain region is at the same potential, every point within that region must be at the same potential, provided no charged body is placed within the region.

It would, therefore, be sufficient to surround our powder-mill with a conducting material, to sheathe its roof, walls, and ground-floor, with thick sheet-copper, and then no electrical effect could occur within it on account of any thunder-storm outside. There would be no need of any earth-connection. We might even place a layer of asphalt between the copper floor and the ground, so as to insulate the building. If the mill were then struck with lightning, it would remain charged for some time, and a person standing on the ground outside and touching the wall might receive a shock, but no electrical effect would be perceived inside, even on the most delicate electrometer. The potential of everything inside with respect to the earth would be suddenly raised or lowered, as the case might be, but electric potential is not a physical condition, but only a mathematical conception, so that no physical effect would be perceived.

It is, therefore, not necessary to connect large masses of metal, such as engines, tanks, etc., to the walls, if they are entirely within the building. If, however, any conductor, such as a telegraph-wire or a metallic supply-pipe for water or gas, comes into the building from without, the potential of this conductor may be different from that of the building, unless it is connected with the conducting-shell of the building. Hence the water or gas, supply-pipes, if any enter the building, must be connected to the system of lightning-conductors, and, since to connect a telegraph-wire with the conductor would render the telegraph useless, no telegraph from without should be allowed to enter a powder-mill, though there may be electric bells and other telegraphic apparatus entirely within the building.

I have supposed the powder-mill to be entirely sheathed in thick sheet-copper. This, however, is by no means necessary in order to prevent any sensible electrical effect taking place within it, supposing it struck by lightning. It is quite sufficient to inclose the building with a network of a good conducting substance. For instance, if a copper wire, say No. 4, B. W. G. (0.238 inch diameter), were carried round the foundation of the house, up each of the corners and gables and along the ridges, this would probably be a sufficient protection for an ordinary building against any thunder-storm in this climate. The copper wire may be built into the wall to prevent theft, but should be connected to any outside metal, such as lead or zinc on the roof, and to metal rain-water pipes. In the case of a powder-mill it might be advisable to make the network closer by carrying one or two additional wires over the roof and down the walls to the wire at the foundation. If there are water or gas pipes which enter the building from without, these must be connected with the system of conducting-wires, but, if there are no such metallic connections with distant points, it is not necessary to take any pains to facilitate the escape of the electricity into the earth.

Still less is it advisable to erect a tall conductor with a sharp point in order to relieve the thunder-clouds of their charge.

It is hardly necessary to add that it is not advisable, during a thunder-storm, to stand on the roof of a house so protected, or to stand on the ground outside and lean against the wall.—*Nature.*

MORMONISM FROM A MORMON POINT OF VIEW.

By DANIEL WEDDERBURN.

DURING a recent visit to Salt Lake City I happened to ask one of the leading Mormons what works, in addition to the Book of Mormon, would give me a fair idea of the religious doctrines professed by the Latter-day Saints and of their history, as they themselves desire to have it told. The gentleman addressed most kindly offered for my acceptance several books, among which were pamphlets by Orson Pratt, one of the twelve apostles of the church, the "Key to the Science of Theology," by Parley P. Pratt, and the "Rise, Progress, and Travels of the Church of Jesus Christ of Latter-day Saints," by President George A. Smith.

So far as religious tenets are concerned, the authority of the works mentioned may doubtless be accepted as final. With regard to the historical portion of the subject it is different, and here a certain allowance must be made for the bias of a religious partisan; but it is not the less interesting to read this brief but stirring history, as it is told by those who played a prominent part in its events. Having studied these books, I shall endeavor to give a short account of Mormonism, as it is described by the Mormons themselves, and as it appears to myself, being personally little predisposed to regard it favorably, but convinced that its case has seldom been fairly stated to the public.

A certain practical importance attaches at present to the subject, for the future position of Mormonism in the Union is among the many difficult political problems now offering themselves for solution in the United States of America. It presents, indeed, upon a small scale, a similar difficulty to that caused by the existence of slavery in the Southern States: as to how far it is possible to maintain political federation between communities differing essentially in their social institutions. The American Constitution is wonderfully elastic, but it has proved impossible to retain slaveholding States permanently within its limits. Is its elasticity sufficient to admit into the Union a State which would legalize polygamy? Hitherto a negative answer has been given by Congress to this question, and the claims of Utah Territory to become a State have been urged in vain; but the steady increase of population and wealth is constantly strengthening those claims, and they cannot much longer be ignored. The fourth unsuccessful attempt to obtain admission as a State of the Union was made in 1872, when the population of Utah already exceeded that of Nevada and Nebraska combined (at the date of their admission), being upward of 105,000; and a memorial to Congress was adopted, praying for admission into the Union as a sovereign State. The constitution then proposed for the State, which was to bear the name of Deseret, was approved by the people of the Territory, with only 368 dissentient votes; it provided for women's suffrage, and minority representation.

The admission of Nevada, Nebraska, and Colorado, all of them neighboring Territories with inferior population to Utah, appears to justify the assertion of the Mormons that the unpopularity of their religion was the sole cause of their exclusion. Had Deseret been created a sovereign State in 1872, the controversy as to polygamy might have entered upon a new and critical phase, as the State Legislature would doubtless have claimed the right to legalize plurality of wives within its own jurisdiction. No such right can be claimed by the existing Legislature of Utah, whose powers are restricted by the provisions of the act of 1850, to which the Territory owes its political existence. All laws of the Territorial Legislature must have the sanction of the Governor (who is appointed by the President of the

United States), and are passed subject to the approval of Congress. The judges of the Territorial Supreme Court are also appointed by the President, so that the control of the Federal authorities is complete over all departments in the Territory, and it is natural that the Mormon community should aspire to a more independent position. It is questionable, however, whether independence would not prove a disadvantage to the Mormons, as tending to bring them into direct collision with popular feeling, which has always been more or less hostile to them throughout the Union, while the Federal authorities have acted a friendly part. During seventeen sessions of the Utah Legislative Assembly, the power of disapproval has only once been exercised by Congress, and then (as might have been expected) in relation to the law of marriage. The Washington Government has afforded protection to the Mormons against local officers and judges, President Grant, in particular, having recently braved considerable unpopularity by removing the Chief-Justice of the Supreme Court of Utah for "arbitrary and illegal conduct" in his dealings with the Latter-day Saints. Again, a few years ago the United States officials in Utah set at naught the Territorial law under which jurors were selected and summoned, rejecting those who professed their belief in Mormon doctrines. Where the value at issue exceeds $1,000, an appeal lies to the Supreme Court of the United States, and a case tried by a packed jury, and given against the municipal officers of Salt Lake City, was accordingly appealed. The unanimous decision of the Supreme Court at Washington was, that the jury had not been legally impaneled, and the judgment of the Utah court was reversed. Great rejoicing was caused at Salt Lake City by this decision in the Engelbrecht case, as proving that the inhabitants of Territories had rights in common with their countrymen, and that there was justice in the United States even for the professors of a very unpopular religion.

It may appear strange that in the freest of lands, and in the latter half of the nineteenth century, a legal doubt should have existed as to whether civil disabilities were attached to any form of religious opinion; but it must be remembered that the evidence of an atheist was very recently rejected in English courts of justice, and the Legislature of North Carolina expelled last year a member, because he conscientiously declared his disbelief in the existence of God. The fact is that, even in Protestant countries, complete religious toleration is limited to certain recognized persuasions, so that feeble and unpopular sects have still to unite in claiming for themselves the same liberty of conscience which has been conceded to all numerous and powerful dissenting bodies. Science now demands from theology absolute and unconditional freedom, and the day can hardly be far distant when theological heterodoxy will cease to involve any civil penalties in a free country. At present the Mormon refugees of the

Rocky Mountains demand only that amount of civil and religious liberty which the Constitution professes to guarantee to every American citizen, and which the Pilgrim Fathers found for themselves "on the wild New England shore." They complain that their enemies have told their story, that their own statements have been ignored, and that no credit has been given to them for an honest attempt, in these latter days, to put in practice the doctrines of the early Christian Church. Even their enemies will hardly deny that they displayed faith, courage, and endurance, when they resolved, after being expelled from one settlement after another, to plunge into the unknown wilderness, and to found a new Zion beyond the existing limits of the United States. These qualities have triumphed over great physical difficulties, and a stranger is astonished at the prosperity which Mormon industry has produced. A carefully-organized system of irrigation has converted a barren desert into a productive garden, and has had the remarkable effect of raising the permanent level of the lake ten feet higher than it was in 1850. Every requirement of the religious community is abundantly supplied by contributions, assessed and collected upon voluntary principles. Besides the immense new Tabernacle, a temple is now in course of construction, almost Egyptian in its massive grandeur, toward which all the faithful contribute, those who cannot afford money giving their labor. The Indians in Utah have been conciliated by the humane policy of feeding, clothing, and teaching, instead of fighting them. The old accusations of violence and cruelty toward Gentile immigrants, or Mormon deserters, if not altogether disproved, have at least been lived down in recent times, and the existence of a military camp near Salt Lake City is now, probably, more unnecessary than it would be at any other town west of the Rocky Mountains. In order to appreciate the tranquillity, sobriety, and steady industry of Deseret (as the Mormons prefer to name their country), it may be contrasted with Nevada, an adjoining State almost identical with Deseret as to soil, climate, and mineral products. The so-called Silver State stands now preëminent in the Union for its turbulent manners, for the number of its liquor-shops, and as being the only State which legalizes public gambling. Of course, Nevada is merely passing through a certain rude stage of her existence, just as California had done before her, and she, too, will one day set her house in order; the remarkable point is that Utah should, alone among the young communities of the far West, have altogether escaped such a condition of things. To many persons this will appear to be sufficiently explained by the fact that the Mormons both preach and practise habits of extreme temperance, almost amounting to total abstinence from every sort of stimulant.

Considerable hostility undoubtedly exists between the Mormons and some of their Gentile fellow-residents; this is greatly due to the bitter attacks of certain local newspapers upon the Latter-day Saints, and upon those who show them any favor. When I was in Salt Lake City, the Governor of Utah Territory was very severely assailed for his alleged partiality toward the Mormons, and a grim hope was at the same time expressed that Mr. Brigham Young might shortly take the place merited by him "at the only fireside, which we know of, large enough to accommodate him and the whole of his family." That such expressions are publicly used in speaking of a man whom the great bulk of the community regard as an inspired prophet, is a sufficient proof that no terrorism is now exercised against dissenters from the dominant church of Utah. To a stranger like myself, desirous of understanding as far as possible the tenets of their faith, a frank and friendly reception was accorded by such of the Mormon leaders as I had an opportunity of visiting. Every explanation asked for was at once afforded, but I do not feel justified in mentioning names, or in repeating any private conversation, although it was probably not intended to be confidential. A passing stranger can only see the external surface of society, and in this respect there is nothing very remarkable in Salt Lake City. The parlor of a flourishing Mormon householder does not differ much in appearance from that of an Englishman who happens to have a numerous family, with a large proportion of sisters or daughters. A new and somewhat startling sensation is, however, experienced during the ceremony of introduction on first hearing the words, "Now, sir, let me introduce you to another of my wives." The strangeness of these words mainly consists in the very fact that they are uttered, not by a dark-skinned barbarian, but by a gentleman answering to the description of the English soldiers given by "Le Conscrit de 1813"—"blancs, bien rasés, comme de bons bourgeois"—and in a room with all the familiar surroundings of civilized domestic life. The public worship of the Church of Jesus Christ of Latter-day Saints, as the Mormons invariably designate their own sect, is conducted with great simplicity, very much as it is in an English dissenting chapel, and the preponderance of ladies is by no means greater than that to which we are accustomed in places of worship generally. The only marked peculiarity is the administration of the Lord's Supper in water instead of wine, and of this sacrament it appears to be customary for all the faithful present to partake, old and young alike. The hymns are sung by a mixed choir of young men and women, and addresses are delivered by eminent Mormon elders. When I was present, the speakers were Mr. Daniel H. Wells, Mayor of Salt Lake City, and Mr. Cannon, brother of the delegate from Utah Territory to Congress. All religious argument was based upon the authority of the Bible, to which the Mormon revelations claim to be *additional*, but in no sense *contrary*. Various Mormon doctrines were touched upon, and special allusions were made to the persecutions undergone by the Saints in past times, and to those which appeared to menace them in the future. Although not yet half a century old, the Church of Jesus Christ of Latter-day Saints has passed through a baptism of fire, and living men can speak with mingled pride and sorrow of personal friends who died as martyrs to their religious faith. Thirty years ago Nauvoo, in Illinois, was a Mormon settlement, almost equal in population and prosperity to Salt Lake City at the present day; those who witnessed its total destruction can hardly be considered idle alarmists, when they allude to the possibility of trials yet to come. The tone of the speakers was thoroughly practical, exhorting to industry and sobriety, to abstention from all stimulants, including tobacco, coffee, and tea, and to the cultivation of all the useful arts, "even those of war, if necessary to the safety of our community." These exhortations were mainly addressed to the juniors present, a saving clause being inserted for those seniors who had borne the burden and heat of the evil days, and who, having now established this mountain refuge for the Saints, might require to "solace decaying nature" with an occasional narcotic. The addresses breathed a tolerant and rational spirit, the doctrines inculcated were simply those of a charitable form of Christianity, and there was no mention of that peculiar domestic institution which sums up in the minds of so many all notions connected with Mormonism.

After all, it is upon "plural marriages" that the interest as well as the hostility of the outer world has always been concentrated; a Mormon is simply regarded as a man with a number of wives, and beyond this most people know little, and care less, as to the doctrines or customs of the Latter-day Saints. Were it not for their polygamy, it seems probable that the Mormons might now enjoy the same perfect toleration which is extended in America to other forms of religious eccentricity, and that Deseret would long ere this have taken her place among the States of the Union. On the other hand, it must be borne in mind that polygamy is a comparatively recent innovation, condemned by the Book of Mormon in the strongest possible terms:

> "The word of God burdens me because of your grosser crimes. For behold, thus saith the Lord, this people (the Nephites) begin to wax in iniquity; they understand not the Scriptures; for they seek to excuse themselves because of the things which were written concerning David and Solomon his son. Behold, David and Solomon truly had many wives and concubines, which thing was abominable before me, saith the Lord; wherefore, thus saith the Lord, I have led this people forth out of the land of Jerusalem, by the power of mine arm, that I might raise up unto me a righteous branch from the fruit of the loins of Joseph. Wherefore I, the Lord God, will not suffer that this people shall do like unto them of old. Wherefore, my brethren, hear me, and hearken to the word of the Lord; for there shall not any man among you have save it be one wife, and concubines he shall have none; for I, the Lord God, delighteth (*sic*) in the chastity of women."

These are the words of "Jacob, the brother of Nephi," and words could hardly be more distinct or emphatic; but theologians can generally manage to explain away inconvenient texts and hard sayings, while in this case it may be held by the Saints that the above injunctions were repealed by the subsequent "Revelation on Celestial Marriage." This tardy revelation, vouchsafed to Joseph Smith shortly before the close of his career, is the sole warrant for plurality of wives—a practice which is general among the Mormon leaders, but not throughout the community at large. With them, as with Mohammedans or Hindoos, polygamy is doubtless very much a question of expense, and I was informed on good authority that probably about one in four of the Saints is the husband of more than one wife. The majority, therefore, adheres in practice to the "Doctrine and Covenants," which book is a recognized authority upon articles of Mormon faith, and declares that "one man should have one wife, and one woman but one husband, except in case of death, when either is at liberty to marry again." The number of wives ascribed to eminent individuals is usually exaggerated, sixteen being the largest number admittedly married to one man, and six constituting the household of a wealthy and influential elder.

The Mormons compare themselves to the Jews, as well as to the early Christians; they have been a persecuted people, driven forth to wander through trackless deserts, and are now living apart from their neighbors in a theocratic commonwealth of their own. Their precedents on behalf of polygamy are mainly drawn from the Hebrew Scriptures; but they also assert that they have in their favor the example of the primitive Christian Church. Without going into their arguments, it may be at once conceded that polygamy was sanctioned by the ancient Hebrew law; but it is not the less out of date in the new world of America, and is a standing peril to the Church of the Latter-day Saints. By an act of the Utah Legislature, the right of suffrage has been conferred on "all American women, native or naturalized," and it hardly seems possible that polygamy can long survive such legislation. At present the extension of the franchise among persons, few of whom are "native" Americans, and many of whom are very imperfectly educated, probably strengthens the hands of the Mormon leaders by swamping entirely the Gentile element. But such an effect is not likely to be permanent, for the rising generation will be educated; in 1871, just after the passing of the act above referred to, sixty per cent. of the girls between four and sixteen years of age were enrolled as scholars throughout Utah Territory, being slightly in excess of the percentage among boys of the same age. Equality between the sexes in education and in electoral privileges must tend to bring about social and religious equality also, and the example of their independent sisters in Wyoming Territory, where women enjoy complete civil rights, will not be thrown away upon the ladies of Salt

Lake City. The tone of public feeling throughout the neighboring States and Territories is more favorable toward "woman's rights" than it is in any other part of the world; and, even if this be partly due to a reaction produced by Mormonism, it cannot fail in time to influence the female electors of Utah. Thus it is possible that a peaceable solution of the difficulty may be found, and polygamy may be abolished, not by external force, but by constitutional action within the Mormon community itself.

Meanwhile, this church of the nineteenth century possesses amazing vitality, and seems to carry us back to a by-gone era of belief, exhibiting as it does the phenomenon of a religious sect heartily convinced of its future mission and claiming the present for its own. While other churches look to the past for all that is best and truest in religion, the Latter-day Saints regard the present also as a period of miracle and revelation. They expect, in the immediate future, the conversion of all who inhabit their vast continent with as serene a confidence as that with which the early Christians seem to have anticipated the evangelization of the Roman Empire. It may be said of them that in theology they maintain the modern doctrine of continuity, rather than ancient theories of convulsion and catastrophe. Accepting, in a literal sense, the Jewish and Christian Scriptures, they apparently entertain no fear lest scientific research should undermine their faith, as they look for a continuous course of revelation, which shall harmonize theology with the general advance in human knowledge.

The title of Parley P. Pratt's recent work, "Key to the Science of Theology," 1874, may seem almost to involve a contradiction in terms; but it indicates the desire of a distinguished Mormon theologian to keep abreast, if possible, of the scientific spirit of the age. Whether the attempt to do this may have proved successful or not, his policy is surely wiser than that which has frequently placed science and theology in opposition so direct, that every conquest of knowledge over ignorance has appeared to be also a victory over religion. Indeed, Mr. Parley Pratt is entitled to a welcome from the lovers of free thought, considering how rarely theologians seek to identify the progress of their own tenets with that of humanity in every department of science and art, and how seldom it is that they do not

> "Grow pale
> Lest their own judgments should become too bright,
> And their free thoughts be crimes, and earth have too much light."

To quote his own words:

> "The creeds of the Fathers seem to have been cast in the mould of other ages, to be adapted to a more narrow sphere of intellectual development, and to be composed of material too much resembling cast-iron; or, at least, not sufficiently elastic to expand with the expansion of mind, to grow with the growth, and advance with the progressive principles of the age. For these reasons, per-

haps more than any other, the master-spirits of the age are breaking loose from the old moorings, and withdrawing from established and venerated systems."

Holding these views, Mr. Parley Pratt has aimed at embodying, in his introductory key, a general view of what he calls the Science of Theology, "in a concise and somewhat original manner and style, as gathered from revelation, history, prophecy, reason, and analogy." The revelation and prophecy referred to and founded upon are partly those accepted by all orthodox Christians, partly those of recent date (such as the Book of Mormon and the Doctrine and Covenants) peculiar to the followers of Joseph Smith. It is hard to reconcile polygamy with "the progressive principles of the age," and with modern ideas as to the social position and dignity of woman; but Mr. Parley Pratt is not without a scientific plea on behalf of his theological dogma. He maintains that—

> "The principal object contemplated by this law is the multiplication of the children of good and worthy fathers, who will teach them the truth, and this is far preferable to sending them into the world in the lineage of an unworthy or ignorant parentage. . . . A wise legislation, or the law of God, would punish with just severity the crimes of adultery or fornication, and would not suffer the idiot, the confirmed, irreclaimable drunkard, the man of hereditary disease, or of vicious habits, to possess or retain a wife; while at the same time it would provide for a good and capable man to honorably receive and entertain more wives than one. . . . The restoration of pure laws and practices has already commenced to improve or regenerate a race. A holy and temperate life; pure morals and manners; faith, hope, charity; cheerfulness, gentleness, integrity; intellectual development, pure truth, and knowledge, will produce a race more beautiful in form and features, stronger and more vigorous in constitution, happier in temperament and disposition, more intellectual, less vicious, and better prepared for long life and good days in their mortal sojourn. Each generation governed by the same laws will still improve."

This sounds plausible enough in theory, and perhaps the result of polygamy as practised in Utah is, that a large proportion of offspring is born to the most energetic, intelligent, and industrious citizens. In an age when there is reason to fear an increasing tendency to "non-survival of the fittest," such a result may be admitted as tending to counterbalance some of the disadvantages attending plurality of wives.

The highest types of domestic animals have been developed under a system of breeding and selection, very similar to that which is advocated in the above quotations, and the burden of proof seems to rest upon those who maintain that a high type of humanity cannot be developed after a similar fashion. Should the Mormons succeed in carrying out practically, for a few generations, any such ideas as are above alleged to be the main objects contemplated in their law of polygamy, they would have fair grounds for the belief that they are destined to inherit the whole earth.

A race of human beings developed (if such a thing were feasible) by strictly scientific selection and culture could not fail to gain the upper hand in the general struggle for dominion, but it remains to be seen whether any success in this direction will attend the system of the Mormons.

> "Our physical organization, health, vigor, strength of body, intellectual faculties, inclinations, etc., are influenced very much by parentage. Hereditary disease, idiocy, weakness of mind or of constitution, deformity, tendency to violent and ungovernable passions, vicious appetites and desires, are engendered by parents, and are bequeathed as a heritage from generation to generation."

These are the words of a leading apologist of polygamy, who founds an argument in his own favor upon this truth, now generally admitted, but almost as generally ignored. It is impossible here to discuss so wide and so difficult a question, and I must limit myself to these few brief quotations from the "Key to the Science of Theology," leaving the reader to judge of their worth.

The series of pamphlets by Orson Pratt contains discussions on a great variety of questions connected with Mormonism. In particular the "Divine Authenticity of the Book of Mormon" is considered at great length, as well as the question, "Was Joseph Smith sent of God?"

Mr. Orson Pratt endeavors to show, in the first place, that to expect more revelation is not *unscriptural;* secondly, that it is not *unreasonable;* and, thirdly, that it is *indispensably necessary.* He then goes on to compare the evidences of the Book of Mormon and of the Bible, alleging that both alike have been confirmed by miracles, and that the prophecies of the Bible, especially those of Isaiah, have been fulfilled in the Book of Mormon and in the history of Mormonism. Throughout his elaborate arguments he assumes the genuineness and authenticity of the Bible, an assumption which he is of course entitled to make in arguing with orthodox Christians. His position is: The truth of the Bible rests upon sufficient evidence, and this evidence is in every way weaker than that which can be adduced for the Book of Mormon—therefore, *a fortiori,* the Book of Mormon is true. Whatever may be the flaw in this syllogism, those whom Archdeacon Paley satisfies cannot fail to have some trouble in disposing of Mr. Orson Pratt. Toward other Christian sects, whose creeds "are an abomination unto the Lord," the Mormon apostle displays but little brotherly feeling. Upon papist and Protestant alike he pours out the vial of his wrath and contempt in language almost too forcible for quotation; but he seeks to base every reproach directed against them upon texts from the orthodox Scriptures. The pamphlet entitled "The Bible and Tradition, without Further Revelation, an Insufficient Guide," is, in fact, a powerful onslaught upon modern Christendom, perhaps as damaging as any that a professed unbeliever could have made, although in this case the assailant accepts with reverence the Christian Scriptures, seeking to found thereon a revelation newer and more complete.

It is somewhat disappointing, if the Book of Mormon is to be accepted as the new revelation, to find it so very inferior, alike in matter and in style, to its great predecessors. Nearly equal in bulk to the Old Testament, it lacks altogether the poetic grandeur and the graphic force of the Hebrew Scriptures, although the Biblical phraseology has been laboriously imitated throughout. It is styled "An Account written by the Hand of Mormon upon Plates taken from the Plates of Nephi. Translated by Joseph Smith, Jr.:"

> "Wherefore it is an abridgment of the record of the people of Nephi, and also of the Lamanites; written to the Lamanites, who are a remnant of the house of Israel; and also to Jew and Gentile; written by way of commandment, and also by the spirit of prophecy and of revelation. Written and sealed up, and hid up unto the Lord, that they might not be destroyed; to come forth by the gift and power of God unto the interpretation thereof: sealed by the hand of Moroni, and hid up unto the Lord, to come forth in due time by the hand of Gentile; the interpretation thereof by the gift of God.
>
> "An abridgment taken from the Book of Ether also; which is a record of the people of Jared; who were scattered at the time the Lord confounded the language of the people when they were building a tower to get to heaven; which is to show unto the remnant of the house of Israel what great things the Lord hath done for their fathers; and that they may know the covenants of the Lord, that they are not cast off forever; and also to the convincing of the Jew and Gentile, that JESUS is the CHRIST, the ETERNAL GOD, manifesting himself unto all nations. And now if there are faults, they are the mistakes of men; wherefore condemn not the things of God, that ye may be found spotless at the judgment-seat of Christ."

The sacred volume is divided into thirteen books, bearing the names of various prophets, one of whom is Mormon. The last book is that of Moroni, who says:

> "Behold I, Moroni, do finish the record of my father, Mormon. Behold, I have but few things to write, which things I have been commanded by my father. And now it came to pass that, after the great and tremendous battle at Cumorah, behold, the Nephites, who had escaped into the country southward, were hunted by the Lamanites, until they were all destroyed; and my father also was killed by them, and I even remained alone to write the sad tale of the destruction of my people. But, behold, they are gone, and I fulfill the commandment of my father. And whether they will slay me, I know not; therefore I will write and hide up the records in the earth, and whither I go it mattereth not. Behold my father hath made this record, and he hath written the intent thereof. And behold, I would write it also, if I had room upon the plates; but I have not; and ore I have none, for I am alone; my father hath been slain in battle, and all my kinsfolks, and I have not friends, nor whither to go; and how long the Lord will suffer that I may live I know not. Behold, four hundred years have passed away since the coming of our Lord and Saviour.
>
> "And now, behold, we have written this record according to our knowledge

in the characters which are called among us the reformed Egyptian, being handed down and altered by us, according to our manner of speech. And if our plates had been sufficiently large, we should have written in Hebrew; but the Hebrew hath been altered by us also; and if we could have written in Hebrew, behold, ye would have had no imperfection in our record. But the Lord knoweth the things which we have written, and also that none other people knoweth our language, therefore he hath prepared means for the interpretation thereof. And these things are written, that we may rid our garments of the blood of our brethren, who have dwindled in unbelief. And behold, these things which we have desired concerning our brethren, yea, even their restoration to the knowledge of Christ, is according to the prayers of all the saints who have dwelt in the land. And may the Lord Jesus Christ grant that their prayers may be answered according to their faith; and may God the Father remember the covenant which he hath made with the house of Israel; and may he bless them forever, through faith on the name of Jesus Christ! Amen."

The record in question professes to contain a history of the American Continent from the date of its first colonization by Jared and his brother at the time of the dispersion from Babel down to the year A. D. 420, when Moroni, the last of the Nephite prophets, buried his plates in the hill of Cumorah. This account of prehistoric America is but a tedious composition, full of battles and slaughter, full of proper names, of reiterations, and of unnecessary phrases. We are told how the Jaredites, emigrants from the valley of Nimrod, who "did carry with them Deseret, which by interpretation is a honey-bee," attained to great civilization and prosperity in North America, and were utterly destroyed by internecine warfare about the year 600 B. C. They were succeeded by a "remnant of the house of Joseph," brought from Jerusalem in the reign of Zedekiah to inherit the land. These appear to have crossed the Pacific Ocean, landing on the west coast of South America, whence they eventually overspread that continent. They separated before long into two distinct nations, known as Nephites and Lamanites, the former migrating from the persecutions of the latter, and sailing "forth into the west sea by the narrow neck which led into the land northward." Through the personal ministry of Jesus Christ, who visited them shortly after his ascension, the Nephites were converted from the Mosaic to the Christian faith, which was in time accepted by the Lamanites also; and for two hundred years they prospered and multiplied, and there was no contention in the land, all things being common among them. This golden age was succeeded by a period of apostasy; "and from that time forth they did have their goods and their substance no more common among them, and they began to be divided into classes, and they began to build up churches unto themselves, to get gain, and began to deny the true church of Christ." A terrible war broke out between the Nephites, now settled in North America (known as the land Desolation), and the Lamanites, who invaded them from the land Bountiful, lying southward of the Isthmus of Darien. This war ended in the annihilation of the Nephites, "an exceeding fair and delightsome people," while a degraded remnant of the Lamanites still survive, after fifteen centuries of rapine and discord, under the name of American Indians. "Now the heads of the Lamanites were shorn; and they were naked, save it were skin, which was girded about their loins; and the skins of the Lamanites were dark, according to the mark which was set upon their fathers, which was a curse upon them because of their transgression." Thus the term *Gentile* is properly used to denote the *white man*, as distinguished from the copper-colored house of Israel, and the Mormons themselves are expressly described as the "Gentile Saints." For the remnant of Joseph a glorious future is prophesied. They, the despised redskins, shall have the land for their inheritance, and it shall be "a land of liberty unto the Gentiles, and there shall be no kings upon the land." They are to be the chief agents in building the New Jerusalem, and will be converted and redeemed before their brethren of Judah.

The story of the plates, from which the sacred book is said to have been translated, first into English, and subsequently into nearly all the European languages, is of some interest from an archæological point of view, and may be told in a few words. They are described as having been found by Joseph Smith in a cyst composed of six stones, smooth on the inner surfaces, and firmly cemented together. This stone box was buried in the side of a hill near Palmyra, in the State of New York. The plates had the appearance of gold, were six by eight inches in width and length, each plate being nearly as thick as common tin. They were filled on both sides with small characters beautifully engraved, and were fastened at one edge with three rings running through the whole: thus bound together they formed a volume about six inches in thickness, a part of which was sealed. Various unsuccessful attempts were made by the enemies of Joseph Smith to obtain possession of these plates, and they finally disappeared, having been examined and described by eleven persons, whose testimony, signed with their names, is added to the Book of Mormon.

The evidence of these persons would have been more conclusive had not all of them been believers in the new prophet; moreover, the disappearance of the plates is not quite satisfactorily explained by the statement that they were restored to the charge of the angel under whose guidance they were discovered. Still the actual existence, as well as the genuine antiquity, of plates such as Joseph Smith is said to have brought to light in 1827, seems to have been sufficiently verified elsewhere.

In 1843, near Kinderhook, Illinois, in excavating a large mound, six brass plates were discovered, of a bell-shape, four inches in length, and covered with ancient characters. They were fastened together with two iron wires, almost entirely corroded, and were found, along with charcoal, ashes, and human bones, more than twelve feet below the surface of a mound of the sugar-loaf form common in the Mississippi Valley. Large trees growing upon these artificial mounds attest their great antiquity, and doubtless they contain much that will reward future investigation. No key has yet been discovered for the interpretation of the engravings upon these brass plates, or of the strange glyphs upon the ruins of Otolum, in Mexico; but when an amount of talent, learning, and labor, equal to that bestowed upon Egyptian hieroglyphics or Assyrian cuneiform characters, has been devoted to American antiquities, we may hope to learn something of those mysterious races whose history the Book of Mormon professes to tell.

But if we admit that the plates themselves may have been genuine, our faith in the founder of Mormonism, as a sincere religious enthusiast, is staggered by his mode of interpreting their contents. He tells us that he found along with the records an instrument, called by him the Urim and Thummim, and described as consisting of "two transparent stones set in the rim of a bow." Through the medium of this instrument, he says that he translated the unsealed portion of these scanty records, the result being a bulky volume in English, but he does not explain whether he used it as a magnifier, nor how it proved to be a Rosetta stone for his hieroglyphics, merely asserting that it was "by the gift and power of God." That Joseph Smith believed in his own mission, his character and career alike appear to indicate, and the many ecstatic visions which he describes were probably real enough to him, but the compilation of the Book of Mormon was an act involving much time and labor, and cannot be accounted for by ecstasy.

In these days of La-Salette and Paray-le-Monial it is, perhaps, too much to say that a miracle, in order to find acceptance among educated persons, must be relegated to a remote age and country, and must be invested with a certain amount of external dignity. It is, however, a severe test of faith to be called upon to accept miracles and revelations from a prophet well known to men yet living as "Joe Smith," and referred to as "Mr. S." in the writings of so eminent a disciple as Mr. Orson Pratt. A most remarkable man Mr. S. undoubtedly was, capable of inspiring alike *inestinguibil odio, ed indomato amor.* The bitter hostility of his opponents was more than equaled by the devoted zeal of his converts, and, although murdered by mob violence at the early age of thirty-eight, he had already so well accomplished his work that the new creed, instead of dying with him, continued to spread with increasing rapidity, and was preached by his apostles and elders in every quarter of the globe. He was a New-Englander, born A. D. 1805, in the State of Vermont, and began to have visions when he was about fourteen years of age. In 1830 the Church of Jesus Christ of Latter-day Saints was first organized at Fayette, in the State of New York, and its headquarters were moved gradually westward, until a considerable settlement was formed in Jackson County, Missouri. Here it was expected that the New Jerusalem would be built, but an organized system of persecution drove the Saints out of the State of Missouri, and in 1839 they took refuge in Illinois, where they built the city of Nauvoo, in Hancock County, on the banks of the Mississippi, and enjoyed a short respite from persecution. But in 1844 popular hostility broke out with increased violence, and Joseph Smith (who had been frequently brought before judicial tribunals, and invariably acquitted) proceeded with his brother Hyrum to Carthage, where they surrendered themselves prisoners on a charge of treason, the Governor of Illinois having promised them protection and a fair trial. On the 27th of June, 1844, a large body of men, with their faces blackened, surrounded the prison, and murdered the two brothers Smith. Several of these men were indicted for murder, and were tried about a year later, but they were acquitted. The persecution of the Mormons did not slacken after the death of their prophet, and in September, 1845, an armed mob commenced burning houses in Hancock County, while the authorities declared that the State was unable to protect the Mormons, and they must therefore go. Preparations were made by Brigham Young, President of the Twelve Apostles, and the other leaders of the church, to explore the Rocky Mountains in accordance with an expressed intention of the deceased prophet, and in February, 1846, the exodus of the Mormons commenced. It was not, however, rapid enough to satisfy their enemies, and in September the city of Nauvoo was burned by an armed mob, after several days' siege, and the remnant of the Mormons was driven across the Mississippi into Iowa. In the spring of 1847 Brigham Young, with a party of pioneers, started from his winter-quarters on the Missouri in search of a place of settlement. On the 24th of July he reached the Great Salt Lake Valley, after a laborious march of more than one thousand miles through an unexplored country. After erecting a fort, and hoisting the stars and stripes upon what was then Mexican territory, President Young hastened back to the banks of the Missouri, and in the fall of 1848 he arrived once more in Salt Lake Valley, with eight hundred wagons, and the main body of the Mormons. The severest hardships were undergone by these people, not only during their march, but during the first two years after settling in this barren valley, four thousand three hundred feet above the sea, but strict discipline was enforced in the camp, and a careful system of rationing was maintained, until an abundant harvest at last put an end to the necessity. In 1850 the Territorial government of Utah was organized by act of Congress, and Brigham Young was appointed Governor by the President of the United States. From that time forward the new colony has continued to prosper and progress with almost unexampled rapidity, in spite of great disadvantages as to soil, climate, and situation.

There are few countries on the face of the globe where the Latter-day Saints have not attempted to preach their gospel, but as a rule their preaching has not been tolerated. The records of their missionary efforts make it obvious enough why they obtain so large a proportion of their converts from Great Britain and Denmark, while so few come from the Roman Catholic countries of Europe; except in Scandinavia and the British Empire, the foreign missions of the Mormons have failed through the opposition of the powers that be, who have not only prohibited the missionaries from preaching, but in many cases have expelled them from the country. Even in Norway, so bitterly hostile were the ecclesiastics as to decide that the Church of Jesus Christ of Latter-day Saints is not a *Christian* sect, in order to deprive it of the protection guaranteed by Norwegian law to all Christian dissenters. Three paragraphs from the Mormon Creed, as stated by Joseph Smith himself, will show the injustice of such a decision:

> "We believe in God, the Eternal Father, and in His Son, Jesus Christ, and in the Holy Ghost. We believe that through the atonement of Christ all mankind may be saved by obedience to the laws and ordinances of the Gospel. We believe that these ordinances are: First, Faith in the Lord Jesus Christ; second, Repentance; third, Baptism by immersion for the remission of sins; fourth, Laying on of hands for the Gift of the Holy Ghost."

It is supposed that a larger percentage of the Danes than of any other nation has hitherto embraced Mormonism, and a Danish newspaper is regularly published at Salt Lake City. Since the separation of Schleswig-Holstein from Denmark, the recruiting-ground of the Mormons has been reduced, as their preaching has been rigidly suppressed in those duchies. Of late years the immigration into Utah from the European missions has varied from one to four thousand persons annually. The most active attempts at propagandism appear to have been made about the years 1852–'53, but in this country a Mormon mission was founded as early as 1837, six years before the "Revelation on Celestial Marriage" had given its peculiar character to Mormonism.

It was not until 1843, thirteen years subsequent to the publication of the Book of Mormon, and to the first organization of the Church of Latter-day Saints, that Joseph Smith proclaimed this new and startling revelation. The style of the document resembles that of the Book of Mormon, but it reveals "a new and an everlasting covenant," distinctly at variance with the teachings of that book already quoted, and justifies the patriarchs, and David and Solomon, "as touching the principle and doctrine of their having many wives." It is addressed to "my servant Joseph," and confers upon him "the keys and power of the priesthood: And verily, verily I say unto you, that whatsoever you seal on earth, shall be sealed in heaven." Upon "mine handmaid, Emma Smith, your wife," on the other hand, obedience and submission are inculcated in the strongest terms. She is required to "receive all those that have been given unto my servant Joseph—And I command mine handmaid, Emma Smith, to abide and cleave unto my servant Joseph, and to none else. But if she will not abide this commandment she shall be destroyed, saith the Lord." The revelation contains twenty-five short paragraphs only; it is somewhat apologetic in general tone, and is full of scriptural quotations and precedents. A considerate stipulation is made for the consent of the first bride, when another is to be espoused: "As pertaining to the law of the priesthood: If any man espouse a virgin, and desire to espouse another, and the first give her consent; and if he espouse the second, and they are virgins, and have vowed to no other man, then is he justified." A marriage contracted under the new covenant, and sealed by the appointed authority, is valid to all eternity, whereas in the case of ordinary married persons death terminates the contract, and for them in heaven there will be neither marrying nor giving in marriage.

Such are the terms of Joseph Smith's "Revelation of Celestial Marriage," which reminds one of the convenient doctrines from time to time revealed to Mohammed upon analogous subjects. One more revelation and prophecy remains to be noticed; it is said to have appeared in the "Pearl of Great Price," published at Liverpool in 1851, and to have been "given by the prophet, seer, and revelator, Joseph Smith," on Christmas-day, 1832. The date of publication is the point requiring verification, and a genuine copy of the pamphlet above named would be invaluable, as the language of the alleged prophecy has no prophetic ambiguity, and the fulfillment has been complete. In a few terse words are described the rebellion of South Carolina, and the consequent civil war, the appeal of the Southern States to Great Britain for aid, the arming of the slaves against their masters, and the outbreak of hostilities with the Indians. If there is any accuracy in the dates as stated, Joseph Smith must have been a man of rare political sagacity and foresight.

At the present day most of our religious creeds and systems resemble the great ecclesiastical edifices of the middle ages; relics of days when faith was stronger and zeal was warmer. These magnificent relics may indeed be renovated by modern hands, and upon a humble scale they can be reproduced, but the power of originating such buildings has passed away, and ecclesiastical architecture is no longer a living art. So is it with the chief accepted systems of religion; they have come down to us in their existing form from periods with which we have nothing else in common; they are not in harmony with the tone of modern life and thought, and could not have been established in modern times. Nevertheless, they stand firmly on their ancient foundations, and will long continue to stand, more or less altered and repaired in accordance with modern exigencies.

But the Mormon church is an exception; it has been founded in these latter days, and may be said to have introduced a new order of ecclesiastical architecture, although ancient materials have been largely employed. Hence the doctrines and history of this church appear to deserve careful study, for it presents to us a living example of what its mightier predecessors must have been in their early career. The extinct dinornis may be studied in the existing apteryx, and thus (borrowing a fresh metaphor) among the fossils of the past we seem to find one recent specimen, still full of organic life, illustrating the laws of growth, the habits, and the constitution of those species whose dry bones alone remain to us now. The living apteryx seems to be doomed ere long to become like its fossil congeners; if so, the time for study and observation is short.

Even those who have least sympathy with the peculiar doctrines of the Mormons may be willing to enter a protest in their favor, when the issue really lies between religious liberty and persecution. They are the only Christian sect that has suffered in our own days severe persecution at the hands of professing Christians, and their cause on that account demands especial sympathy from all who advocate absolute religious toleration.—*Fortnightly Review.*

MORE CONCERNING MECHANICAL TOOLS.[1]

BY REV. ARTHUR RIGG, M. A.

CUTTING edges are sometimes doubled, and thus the chisel passes into another group of tools—shears. The most common of these is the ordinary household scissors opened and closed by hand; when required for heavier work, then one handle is fixed in a vise, and both hands can be employed upon the other lengthened arm (*see* Figs. 1 and 2). At other times this double chisel opens with a spring, and then the workman only employs himself in closing such upon their work (Fig. 3). Compound lever power is sometimes introduced, and, as an example of this, here is a pair of very light shears called the "little giant" (Fig. 4), the mechanical contrivances in which are so adjusted that we can, smoothly and without jar, cut an iron rod one inch wide by one-quarter inch thick. The lightness of the tool and the ease in cutting are very noticeable. It is an American contrivance, and the bar of iron is cut with the same ease as though it were of lead. This results to some extent from both jaws approaching each other. The arrangement of levers, cams, and stays, is worthy of examination after the lecture.

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[1] From a lecture delivered before the London Society of Arts.

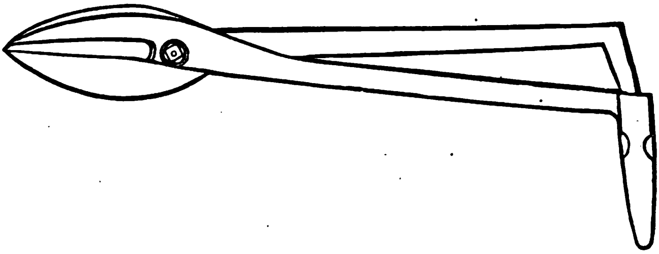

FIG. 1.

The use of the chisel, however skillfully handled, is not satisfactory over a surface wider than itself, although widened and made two-handed, as Fig. 5, and although the gouge has succeeded, or rather been planned to precede it, there is still a tendency almost unconquerable for the tool to follow the leadings of the fibres rather than cut through them at a very slight obliquity.

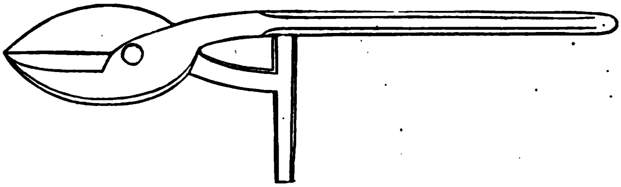

FIG. 2.

The only guidance either the axe, the adze, the pick, the gouge, or the chisel receives, is from the skill of the workman. Hence these tools produce such different work in different hands. However much it may be desirable to encourage skill in the workman, it is quite as desirable to furnish him with implements which shall make the least

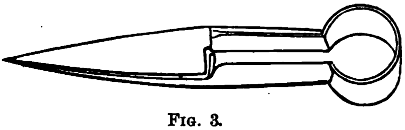

FIG. 3.

demand upon the exercise of this skill—which shall, in fact, so assist the skill in one or more directions as to permit all its care in some other direction. The assistance which the chisel needs is such as shall not only prevent it running deeper into the timber than is desired, but shall enable it to be used with equal facility upon a broad as upon a narrow surface.

Given a rough piece of timber, nine inches wide and five feet long, to be smoothed by tools guided only by the handicraft skill of the workman, setting aside the adze as dangerous and unsuitable, the probability is, that the tools selected would be gouges and chisels of various breadths and curvatures. The order of use would probably be, first, the narrow and deeply-curved gouges, ⌒, these to be followed by the shallower and broader, $\underset{A\qquad B}{\frown}$, these again to be followed by the chisels, using in the first place a chisel wider than A B.

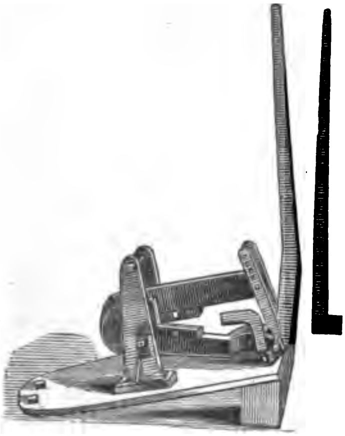

FIG. 4.

Let us consider what these tools would respectively accomplish if the timber is rough, as from the axe or pit-saw. The small gouge would corrugate the surface, ‿‿‿‿; the second gouge would enlarge the corrugation to this, ‿‿‿‿; and the chisel might render these more irregular. Such considerations as these, combined doubtless with others, led to the designing of what may be generally called the "guide principle," and this has been extended to various branches of artisan labor. At present we are only concerned with the application of this principle to gouges and chisels. This guide principle may consist of a guide as to the depth of cut, or as to the form of the

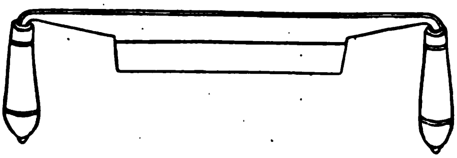

FIG. 5.

surface, or as to the direction of travel, or as to the correction of cross or longitudinal irregularities of surface.

The guide as to depth of cut is that which probably first presented itself as an important appendage to a chisel, and it has led to a form of tool of a very useful construction, although of limited range. The instrument is called a "spoke-shave." In this case the tool is that in Fig. 5 with the guide principle introduced, the depth of cut being determined by the nearness of the edge to a parallel wooden handle.

This tool, owing to the position of the application of the power, viz., the hands, and the tendency of resistance by the work to turn the whole tool in the hand, is not of general use; where, however, the curvature of surface varies, the parings to be removed are light, and the workman can have convenient access, the tool is one capable of doing good work, and, in some respects, possesses advantages over the plane, to which it probably formed an introduction.

The plane, in its most simple form, consists of a chisel inserted at an angle into a box, generally of wood, and with the cutting edge of the chisel projecting through the bottom of the box. If the actions of a workman be noted as he is smoothing wood with a chisel alone, it will be seen that he holds the bevel edge on the wood, and so elevates or lowers the handle as to secure a proper and efficient cut. Then he advances the tool in a line at right angles to its cross-section. If, now, instead of thus continuing to hold the tool, the chisel was so fixed in a movable piece of wood as to be at the same angle as the workman required, then, if the mouth were broad enough, and the instrument were propelled along the wood, a shaving would be removed very nearly the same as that obtained from the chisel alone.

In the arrangement thus sketched the workman would be relieved from the care needed to keep the tool at a constant angle with the surface of the timber. There is, however, a fixity of tool here, and consequently an optional or needful adjustment called for by any varying condition of the problem cannot be had. When operated upon by hand alone, if an obstacle to the progress of the tool is presented, as, for instance, a twist or curl in the fibre or grain of the plank—the presence of a knot—then the workman by hand can adjust the handle, and so vary the inclination of the cutting edge as the circumstances of the case require. Not so if the tool is securely fixed in a box as described.

While, therefore, one gain has been had, one loss has been encountered. Can the gain be made to more than counterbalance the loss? This can only be answered by observing the defects of the primitive plane, as hitherto described, and noting what hopeful elements it contains.

The front of the sole of the box will clearly prevent the penetration of the incased chisel into the wood, because it cannot now be drawn to follow the fibre, should it lead inward. Suppose, however, that in the progress of the work such a place has been reached as would have so drawn the chisel inward. What will happen? Either the strength of the indrawing fibre will be so great that the workman will be unable to propel the tool, or, if not thus impeded, he must by extra effort separate the fibre and so release the tool. This separation, however, will not be by the process of cutting, but by that of tearing, and shavings so torn off will have left their marks in the roughnesses which attend the tearing asunder of fibrous woods. Thus the tool will defeat the very object for which it was designed.

Now, what is it which so forcibly draws, or tends to draw, the tool downward below the surface of the timber? The forces in operation are the hand of the workman and the tenacity of the fibre. If the tenacity is greater than the power, the workman must stop. That the tool cannot follow the direction of the fibre is clear, because the front part of the wooden sole forbids the penetration; but that it may be brought to a standstill, or must tear off the fibre, is also very clear. The mechanician has therefore to consider how to defeat these tendencies, which, as now sketched, result from a collision between the indrawing strength of the fibre and the power of the man to cross-cut the fibre by the tool, or else to tear it asunder and leave the surface rough.

Since the tool, as now contrived, cannot efficiently cross-cut the resisting fibre, and since that fibre has to be removed, the object must be either to prevent such an accumulation of fibres as will stop the progress of the tool, or to destroy the fibre piecemeal as it is operative for hinderance. Both plans have been adopted. A consideration of the former may prove introductory to the latter, which appears in almost all attempts to perfect this tool and its appended contrivance.

As the tool progresses, and the fibres become more and more impeding, it will be clear that a portion of this impediment results from a condensation of the fibre in the mouth of the wooden box. The more numerous the fibres admitted here, the greater will be the condensation. This state of affairs can be partially obviated by a narrowing of the mouth of the plane; such an act, of course, requires that the introduced chisel should enter less deeply into the timber being operated upon. Although thus abated, the cause is not removed, and even if so far abated as to prove no real impediment to the workman, yet the quantity of material removed on each occasion will be so small that the tool becomes one for finishing work only, and not for those various operations to which its present powers enable artisans to apply it.

To be the useful tool it is, the mouth must not be so narrowed, nor the inserted chisel so withdrawn, that the shaving is thus the thinnest possible. This led to a contrivance now almost universal, that of breaking the fibre so soon as it is separated from the piece of timber. The designer seems to have considered that, as soon as a short length of shaving had been removed, it would be well to destroy the continuity of the fibre, and so prevent an accumulative resistance from this cause. Hence, instead of allowing the cut-off fibres to slide up the inserted chisel, he bent them forward, in fact, cracked them, and so broke the cumulative indrawing force of them. This he accomplished by the use of what is now called the back-iron, and henceforth the boxed-in chisel loses its identity, and must be regarded as part of an independent tool.

The tool thus built up is called a plane, and from its general utility, and capability of adaptation to various forms and conditions, it is well deserving of the high opinions entertained of its powers. Three forms of this tool are in general use in English workshops, called the "jack," the "trying," and the "smoothing" planes. These are on the bench of all workers in smooth, straight-surface wood. Although externally alike except in size, they are yet used for different purposes, and each has a specialty met with in its construction. These specialties may now be considered.

After the wood has passed from the sawyer into the hands of the carpenter, the surface undergoes those operations which render it true and smooth. These three planes do this work. The "jack," usually about fifteen inches long, and the "trying" plane, ranging from eighteen inches to twenty-four inches long, but, in exceptional cases, far exceeding these dimensions, are to external appearances alike; indeed, some regard the different handles as the only distinctions between them, and that these handles show which must be used for rough work and which for smooth (*see* Fig. 8 as an example of the handle of a "jack-plane," and Fig. 9 as an example of a "trying-plane handle"). This is an error. There are other differences, but the main and leading one is the different form given to the edge of the cutting-iron.

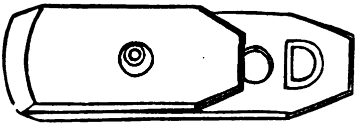

Fig. 6.

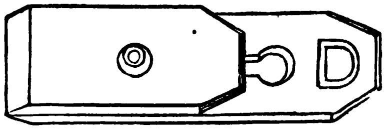

Fig. 7.

If the iron of the "jack" plane be looked at from the front end of the plane, the form of the edge will be curved, as in Fig. 6; but the iron of the "trying" plane is straight, as in Fig. 7. Upon the curvature of the edge depends the efficient action of the "jack."

Sufficient has been said of the tendency of the fibre to draw the tool downward; but it must not be forgotten that the same adhesion of fibre to fibre takes place between the surface-fibres as among those below the surface. If tools excluded from this course of lectures had entered, we should have found that these connecting surface-fibres are separated by the addition of certain supplementary appendages to the tools. The depth to which the plane penetrates has led to the combination in one edge of such supplementary parts.

For the purpose of separating the surface connecting fibres, the jack-iron is convex. Note now its action. The convex sharp edge is pushed along an horizontal plank, penetrating to a depth determined by the projection of each vertical section below the sole of the plane. The ends of this convex edge are actually within the box of the plane; consequently (sideways) all the fibres are separated by cutting, and are therefore smooth and not torn. The effect of this upon the entire surface is to change the surface from the original section to a section irregularly corrugated. The surface after using the "jack" is ploughed, as it were, with a series of valleys and separating hillocks, the valleys being arcs from the convexity of the tool, and the separating hillocks being the intersections of these arcs. All traces of the tearing action of the saw have been removed, and from a roughened but level surface a change has been made to a smooth but in cross-section an undulating one.

The mechanician's next object is to remove these lines of separation between the valleys. For this, the trying-plane is required. The trying-plane is longer than the jack, because the sole of the plane which is level is, so far as its size goes, the counterpart of that which the surface of the wood is to be; further, the trying-plane should be broader than the jack, because its object is to remove the valleys, and not to interfere with the wood below the bottoms of the valleys. If its action passes below the bottoms of the furrows, then occasion arises for cutting the side-connection of the fibres, and, however a workman may sharpen the edge of his trying-plane for this purpose, he in one respect has destroyed one object of the plane, because, so soon as the iron penetrates below the surface, so soon does the effect of the jack-action begin to reappear, and the cutting edge should pass from the shape shown in Fig. 8 to the shape in Fig. 7. The result of

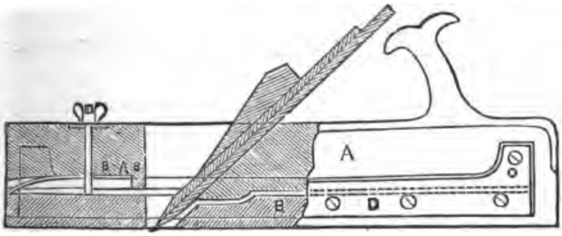

Fig. 8.

the trying-plane following the jack is to remove all the elevations of wood above the valleys the jack left; and, secondly, to compensate by its great length for any want of lineal truth consequent upon the depth of bite of the jack. Again, the mouth of the trying-plane is much narrower than that of the jack; hence the shavings removed are finer; therefore the slope of the iron, or its inclination to the wood, may be less than is the iron of the "jack"—hence the line of cut is more nearly accordant with that of the fibre, and by so much the surface is left more smooth from the trying-plane than from the jack, as there is more cutting and less tearing action than in the jack. The reasoning hitherto pursued in reference to the purpose of this sequence of a jack and trying plane might and does legitimately produce the conclusion that, after the trying-plane has done its duty, the work is as perfectly finished as it can be. Custom, and perhaps other considerations, have established that after the long trying-plane must follow the short and almost single-handed smoothing-plane. So far as the form of the iron of the smoothing-plane is concerned, there is no difference between it and the one used in the trying-plane; each (as across the plane) is straight, the corners being very slightly curved, but only so much as to insure that they do not project below the line of the cutting edge.

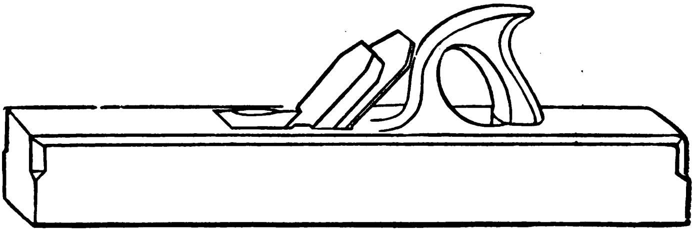

FIG. 9.

The facet edge and inclination of the cutter to the work, and the position of the back-iron, are now under consideration.

It would seem that, while the trying-plane leveled down all the elevations left by the jack, and brought the surface of the wood as a counterpart of that of the plane, there might be, in the fibre or grain of the wood, twists, curls, and other irregularities, which, while leveled, were yet left rough in consequence of the direction in which the cutting edge came upon them. Indeed, this cutting edge in a long plane, which must advance in the direction of its length, must at times come across a large number of surfaces where the fibre is in opposite directions. The consequence is, that there will be various degrees of smoothness; for good work these must be brought to uniformity. This is effected by passing a short-soled plane over the respective parts of the surface in such directions as observation may suggest. Hence the smoothing-plane is of use chiefly to compensate for such changes in the direction of the fibres of the wood as the longer length of the trying-plane could not conveniently deal with. Hitherto, we have regarded the plane as arranged with a "guide principle" which shall always repeat a straight, level surface. The guide may, however, be the counterpart of any required surface. The plane made of iron, now in my hand, has an elastic steel sole, which, by means of adjusting screws, enables a workman readily to convert a straight-faced sole into one either concave or convex. This is an American production (*see* Fig. 10).

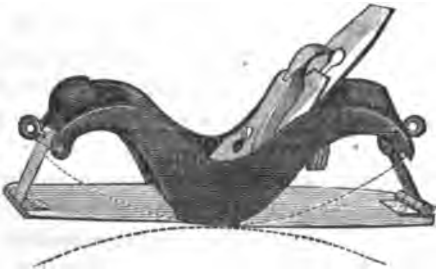

FIG. 10.

There is also in this and other planes a mode of fixing the iron which deserves more general adoption than it receives, viz., by a cam-action. It will often be noticed that, where the holding-wedge binds on the box of the plane in our ordinary planes, the wood has split. This arises from a commendable but, in this case, too strict a care for a good fit; hence the wedge is made tight where it should be slack.

WHAT AMERICAN ZOÖLOGISTS HAVE DONE FOR EVOLUTION.[1]

BY PROFESSOR EDWARD S. MORSE.

II.

IN the "Memoirs of the American Academy of Sciences" may be found a profound mathematical essay "On the Uses and Origin of the Arrangement of Leaves and Plants,"[2] by the lamented Chauncey Wright. After discussing the laws of phyllotaxy, and showing that the botanist is wrong in supposing this a law at the outset, Mr. Wright states "one of the utilities, so to speak, in the apparently undeviating arrangement of leaves, to be the distributing of leaves most rapidly and thoroughly around the stem, exposed more completely to light and air, and provided with greater freedom for symmetrical expansion, together with more compact arrangement of bud;" and he asks, "What has determined such an arrangement of vital forces?" Theory of types would say, their very nature, or an ultimate creative power. Theory of adaptation would say, the necessity of their lives, both outward and inward; or the conditions, both past and present, of their existence.

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[1] An address delivered at the meeting of the American Association for the Advancement of Science. Read at Buffalo, New York, August, 1876, by Edward S. Morse, Vice-President of Biological Section.

[2] "Memoirs of the American Academy," vol. ix., p. 379.

Whatever tends to show modification in the markings, color, size, food, or change in the variety of habits manifested by animals, furnishes just so many indications of the unstable character of what had before been considered stable, and gives an infinitely wider field for those unconscious selections whose operations are coincident with every change in the physical features of the earth. On the theory of derivation additional confirmation is given to the deductions of geologists based upon the stratigraphical and paleontological evidences of the rocks. The survival of a marine crustacean in the deeper waters of Lake Michigan, as discovered by Stimpson, coupled with similar occurrences in the lakes of Sweden, suggests the past connection of these waters with the ocean. In the same way the persistence of arctic forms on high mountain-tops indicates the existence in past times of wide-spread glacial fields. The interesting discoveries of Mr. Ernest Ingersoll, in the Rocky Mountains, of the occurrence of two species of marine mollusks and living crabs belonging to marine forms, and tiny air-breathing mollusks peculiar to the Gulf coast and West Indies, point as distinctly to the past connection of that region with the ocean as the records of marine life left in the rocks. And more than this, the survival of these few forms gives us a conception of the thousands of animals which have succumbed to the changed conditions. Connected with the evidences of recent elevation of this region are the discoveries of Marsh in finding that, when the gill-bearing salamander *Siredon* is brought down from the colder waters of the Rocky Mountains to the warmer waters below, a complete change takes place in a loss of the gills and the conversion of the animal into the air-breathing genus *Amblystoma*.

This exhibits on a wider scale the experiments often performed in keeping tadpoles in the dark and cold, and indefinitely retarding their development, thus forcing them, as it were, to retain their earlier condition. Among the many millions of individuals of Amblystoma, some must have presented the anomaly of a premature development of their ovaries before the larval stage had passed away (similar cases being observed among insects), and thus it has been possible for them to perpetuate their kind in this stage. The Axolotl, having the longest persisted in this mode of growth, has become, as it were, almost fixed in these retrograde characters, only a few examples being known in which the creatures have lost their gills and assumed the mature characters of Amblystoma, but with Siredon a change takes place with a proper change of surroundings.

To American students we are indebted for most valuable contributions regarding the effect of cave influences on animals living within their boundaries. Looking at the cave fauna with its peculiar assemblage of animals, it would seem that here, at least, the question as to the effects of certain external influences, or the absence of others in modifying structure, might be found.

Many years ago the editors of *Silliman's Journal* addressed a letter to Prof. Agassiz respecting the blind fishes of the Mammoth Cave, and asked his opinion as to whether their peculiar structure was due to their cave life, or whether they had been specially created. Agassiz's[1] reply is consistent with his belief. He says, "If physical circumstances ever modified organized beings, it should be easily ascertained here." He then expresses his conviction that "they were created under the circumstances in which they now live, within the limits over which they range, and with the structural peculiarities which characterize them at the present day," adding frankly, however, that these opinions are mere inferences.

With the contributions on cave insects by the eminent zoölogist Schiödte, and our own naturalists as well, we have now overwhelming proof that the blind fishes and numerous other cave animals are marked with peculiarities impressed upon them by the unusual environments to which they have been subjected.

In a work on the animals of the Mammoth Cave, by Dr. A. S. Packard and Prof. Putnam, the first-named writer quotes the results of Schiödte, wherein he shows the existence of twilight animals in which but slight modification occurs, while in darker places the changes become more profound.

Dr. Packard[2] sums up the results of his work as follows: "We then see that these cave animals are modified in various ways, some being blind, others very hairy, others with long appendages; all are not modified in the same way in homologous organs, another argument in proof of their descent from ancestors whose habits varied as their out-of-door allies do at present."

Prof. E. D. Cope,[3] in an article on the fauna of Wyandotte Cave, in commenting on the loss of eyes in cave animals from absence of light, and consequent disuse, says that, to prove it, "we need only to establish two or three propositions: 1. That there are eyed genera corresponding closely in other general characters with the blind ones. 2. The condition of the visual organs is in some cave type variable. 3. If the abortion of the visual organs can be shown to take place coincidently with general growth to maturity, an important point is gained in explanation of the *modus operandi* of the process." He then proceeds to point out a number of related genera in which the external ones present eyes, while the cave forms are blind. As to variability, he cites the blind siluroid fish from Conestoga, Pennsylvania, showing that, while all of several specimens were blind, the degree of atrophy was marked not only in different fishes, but even on different sides of the same fish. In some the corium was perforate, in others it was imperforate. In some the ball of the eye was oval, in others collapsed.

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[1] *American Journal of Science*, second series, vol. xi., p. 128.

[2] "Life in the Mammoth Cave," p. 27. [3] *American Naturalist*, vol. vi., p. 415.

We have in the meagre fauna of the caves convincing proof of the gradual undoing of parts—so to speak—on the withdrawal of influences favorable to them; even so exquisite a structure as the eye as a result of selection almost inconceivable, yet not only becoming rudimentary, but almost disappearing, by the withdrawal of those influences which were in part conducive to its building up. So distinct are these undoing stages that, were we sure of the stable variability of all of them, we could with certainty indicate the relative age of each cave inhabitant.

Prof. Alpheus Hyatt and Prof. E. D. Cope almost simultaneously established a number of propositions relating to certain large groups of animals which had never been recognized before. The theory of acceleration and retardation in which certain groups acquire rapidly new characters, while corresponding groups acquire the same characters more slowly, forms a portion of the theory of these naturalists. Prof. Hyatt has shown among Ammonites a parallel between the life-stages of the individual and similar stages in the group based upon an examination of suites of specimens as studied by him in Europe and America. It is utterly impossible to do the slightest justice to the thoroughly original views of these gentlemen without the aid of explanatory diagrams. While reluctantly abandoning the attempt, I must at the same time express the regret that neither of these investigators has seen fit to present to the public an illustrated and simple outline of the main features of their theories and the facts: Prof. Cope basing in part his propositions on groups of animals, many of which comprise fossil forms brought to light in the West, of which but few restorations have yet been made; and Prof. Hyatt basing his work on fossil Ammonites from the Jurassic and adjacent beds of Europe, of which but one complete collection is to be found in this country.

Surely, with this unfamiliar material, an excuse may be offered in not attempting a popular presentation of propositions and laws, some doctrinal and others theoretical, which must yet be looked upon as profound and permanent additions to the philosophy of evolution. A reference may be made to Prof. Cope's essays, entitled "Origin of Genera," "On the Method of Creation of Organic Types," "Consciousness in Evolution," "On the Theory of Evolution," and numerous other memoirs from which may be gathered the author's views on the subject. The essays of Prof. Hyatt, "On the Parallelism between the Different Stages of Life in the Individual and those in the Entire Group of the Molluscan Order Tetrabranchiata," "Reversions among Ammonites," "Evolution of the Arietidæ," "Genetic Relations of the Angulatidæ," "Abstract of a Memoir on the Biological Relations of the Jurassic Ammonites," are altogether too technical to condense into an address of this nature. It need hardly be mentioned that in these memoirs invaluable contributions are made to the doctrines of natural selection. And now we come to the most difficult part of our work: to compass within the limits of a few pages the magnificent discoveries of Leidy, Marsh, and Cope, in the rich fossiliferous beds of the West. The wonders are so unique and varied; they have been poured upon us with such prodigality of material and illustration, that one is baffled in an attempt to compass their characters, or to picture them as realities. When Darwin offered the imperfection of the geological record as possibly accounting for the absence of intermediate forms which might have existed, he was at once met by a series of protests so strenuous, and at the same time so specious, that they had their full weight in staying the force of that prophetic chapter. Darwin, in this chapter, distinctly stated that not only were there forms which had never yet been seen, owing to the imperfection of the geological record, but that time might possibly bring them to light, and, when discovered, we should have revealed to us intermediate characters which would connect widely-separated groups as they are recognized to-day.

Behold the prophet! Animals have been discovered, not only showing the characters of two widely-separated groups, but in some cases of three groups as they now appear. How distinct the hoofed quadrupeds, the carnivora, and the rodents, appear to-day! Yet here are discovered ancestors of these widely-separate groups, in which are contained in one individual the characters of all three! Of the ungulates with the perissodactyle foot, there have been discovered a large number of tapiroid forms allied to Paleotherium; others which, like Anchitherium, wonderfully fill the gap between the horse and forms lower down; a large suite of rhinocerotic creatures of strange character and enormous size; a great number of species of three-toed horse, some no larger than foxes, and with these a perplexing maze of deer, antelopes, sheep, camels, hippopotami, and pig-like animals, ruminant-like beasts, some of them not larger than an ordinary squirrel: a curious group, comprising a large number of species with characters intermediate between the pigs and ruminants. Prof. Flower, the great English osteologist, confesses that these forms completely break down the line of demarkation between them, and adds that "a gradual modification can be traced in the characters of the animals of this group, corresponding with their chronological position, from the earlier more generalized to the latest comparatively specialized forms, thus affording one of the most complete pieces of evidence that are known in favor of a progressive alteration of form, not only of specific, but even of generic importance through advancing ages." The probable home of the Camelidæ has been revealed in the discovery of llama-like creatures, gigantic mammals, in some cases exceeding the elephant in size, but with a diversity of characters hitherto unseen either in recent or fossil forms, combining as they did the characters of perissodactyle and proboscidian.

A numberless variety of Carnivora, many of them embracing the most generalized groups, have been brought to light, such as creatures between the wolf and the opossum, generalized dogs, and sabre-toothed cats.

A great many species belonging to the Rodentia, Insectivora, and Chiroptera, have been identified; still more wonderful is a group of creatures so unlike any beast heretofore known that Prof. Marsh has made a new order to include them under the name of *Tillodontia.* They combine the characters of several distinct groups, namely, the carnivores, ungulates, and rodents, and some of them in size equaling the tapir. Of great interest also is the discovery of fifteen new genera, belonging to low forms of primates. All of these creatures, embracing hundreds of species, are generalized in a high degree. New orders have been erected to embrace some of them. One has only to understand the specialization of modern animals to appreciate the generalized character of these early forms.

Prof. Marsh has shown that all the ungulates in the Eocene and Miocene had upper and lower incisors; and, again, that all the Eocene and Miocene mammals, including the Carnivora, had two of the wrist-bones, the scaphoid and lunar, as distinct bones.

The class of birds so long represented as a closed type can no longer occupy that isolated position. The proper interpretation of archæopteryx has, in the discoveries of Marsh, new interest. He has discovered a number of species of birds, for which a new sub-class is made. This sub-class will embrace two sub-orders, one in which the creatures had teeth contained in grooves in the jaws; the other had true teeth in the sockets. The first were swimming-birds of gigantic size, with rudimentary wings; the second embraced small birds, with powerful wings and bi-concave vertebræ.

Prof. Cope has also brought to light a remarkable gigantic bird from the Eocene of New Mexico; its size indicates a species with feet twice as large as those of the ostrich. He shows it to be distinct from any of the genera of *Struthionidæ* or *Dionornithidæ.* Besides all these wonders, a host of new forms of reptiles and fishes have been discovered by these indefatigable explorers—huge pterosauria discovered by Marsh with a spread of wing of twenty-four feet; and of more special interest is the fact that no trace of teeth can be found in the jaws.

It is impossible for me to more than allude to these remarkable additions to our knowledge of these early forms, and until they have all been figured with natural outlines, and perplexing questions as to priority in discovery rectified, it will be difficult in some cases to accredit individual work. But in the light of these profound revelations, how blind seem the attempts to establish a classification on the forms heretofore familiar to us, and to rear these into circumscribed groups between which it was asserted no forms of intermediate kinds were to be expected! With the twenty-five or thirty species of fossil horses at our command, some with four toes, others with three, in various stages of reduction, it is interesting to bring back to mind the earnest Geoffroy St.-Hilaire painfully endeavoring to trace the genealogy of the horse, with a few widely-separated forms of extinct mammals as his only guide in the work.

The special investigations of Marsh and Leidy reveal an almost unbroken line from our present horse with its simple toe, and two rudimentary metatarsals in the shape of the splint-bones, to a creature in which metatarsals support rudimentary toes, and still other forms in which these rudimentary toes are working-toes, and below that again another form in which a fourth toe is seen as a rudiment, till forms are reached in which all the toes rest on the ground. It is still more striking to study attentively those earlier generalized horses with four toes, and follow the successive reduction in the number of toes as the later formations are reached, till in the latest deposits and at present we have the modern specialized horse with but a single toe, the lost toes represented by two slender bones hidden beneath the flesh. And now comes crowning proof that our modern horse has been derived from some three-toed progenitor, for in certain instances horses have come into existence with splint-bones developed into sturdy bones sustaining at the extremities phalangeal bones, and outside accessory hoofs! Such freaks of Nature demand an explanation. They receive a rational one through the theories of Darwin. Without the law of reversion, we are left in blind bewilderment.

While all these facts in overwhelming array testify to the extreme mutability of forms, induced oftentimes by apparently the most trivial of causes, and set at rest the question as to the fixedness of species, they show at the same time the richness of that store from which by natural selection forms may be selected.

Realizing the uniformity of Nature's laws, the human mind bravely asks, "Do these wonderful interpretations throw any light upon the origin of man?"

Rigidly adhering to the inductive method, science is prepared to show that man did not appear suddenly and free from those animal proclivities and passions which make him a sinful creature, but that he has risen from a lowly origin, and his passions and desires, but feebly repressed, may be as surely traced to ancestral traits, as the aberrant muscles in his structure may be recognized in some degraded progenitor. And in proof of this there is established a series of facts of precisely the same nature as is seen in those discoveries which link the horse in an almost unbroken line to earlier and more generalized animals.

It is instructive to read the discussions in relation to man's position in Nature as represented by Agassiz, Morton, and others.

The position that these eminent men were justified in taking shocked the Church, and received from her the same vigorous denunciations that Darwin was forced to bear at a later day.

The systematist, in formulating the separate species and genera of the apes and monkeys, was early led to see that man also in various parts of the world presented differences quite as striking, and if it were assumed, as indeed it was, that the peculiarities among men were only varietal, then it could be claimed with equal emphasis that the differences among apes were only varietal. Agassiz, in his keen grasp of things, readily saw this, and, since the races of men revealed differences just as specific in their characters as the animals immediately below them, he was forced to admit the plurality of origin of the human race. He says:

> "Unless we recognize the differences among men, and we recognize the identity of these differences with the differences which exist among animals, we are not true to our subject, and, whatever be the origin of these differences, they are of some account; and if it ever is proved that all men have a common origin, then it will be at the same time proved that all monkeys have a common origin, and it will by the same evidence be proved that man and monkeys cannot have a different origin."

He confesses that he "saw the time coming when the position of the origin of man would be mixed up with the question of the origin of animals, and a community of origin might be affirmed for them all." With these convictions it is not surprising that he should have been led to express the opinions regarding the diversity of the human race that we find recorded.

Agassiz, in the meetings of the American Academy, repeatedly and in various ways illustrated the diversity of the human race. In one place he alludes to the difficulty in defining the species of man, and says the same difficulties occur in defining the species of anthropoid apes. We quote from the records:

> "The languages of different races of men were neither more different nor more similar than the sounds characteristic of animals of the same genus; and their analogy can no more be fully accounted for on any hypothesis of transmission or tradition than in the case of birds of the same genus uttering similar notes in Europe and America."—("Proceedings of the American Academy," vol. iii., p. 6.)

Again, in a later volume, he expresses a general disbelief in the supposed derivation of later languages from earlier ones. He regarded each language and each race as substantially primordial, and ascribed their resemblances to a similarity in the mental organization of the races.

This extract illustrates the extremity to which one is logically driven if he accepts the hypothesis of special creation, and these words are quoted, not with the belief that at the present time they would have been uttered, but as illustrating the necessary admissions with the theory of plurality of origin. In precisely the same manner that Whitney, Müller, and other eminent philologists, have shown the outgrowth of present existing languages from primitive forms of language, so science is prepared to show the outgrowth of present men from primitive forms of animals. Agassiz was bitterly assailed by the Church for the bold attitude he assumed regarding the plurality of origin of the human race, though now that science will show that after all man has originated from a common centre, it seems no better satisfied. The facts bearing on man's lowly origin have been fully contributed by American students, and, as all intelligent men understand the bearing of these facts on the question, it is only necessary to allude to them here. If man has really been derived from an ancestor in common with the ape, we must expect to show—1. That in his earlier stages he recalls certain persistent characters in the apes; 2. That the more ancient man will reveal more ape-like features than the present existing man; and, 3. That certain characteristics pertaining to early men still persist in the inferior races of men.

Prof. Wyman[1] points out certain resemblances between the limbs of the human embryo and the permanent condition of the limbs of lower animals. In some human embryos about an inch in length he found that the great-toe was shorter than the others, and, instead of being parallel to them, projected at an angle from the side of the foot, thus corresponding with the permanent condition of this part in the Quadrumana.

In some observations made on the skeleton of a Hottentot, Prof. Wyman[2] calls attention to the complete ossification of the nasal bones, no trace of a suture remaining. This was more noticeable as the individual was young, and the other bones were immature, and had an interest "in connection with the fact that the nasal bones are coössified at an early period in the monkeys and before the completion of the first dentition in gorillas and chimpanzees." Careful measurements of the pelvis also revealed quadrumanous features, though "the resemblance is trifling in comparison with the differences."

In a study of the crania, Wyman[3] found differences in the relative position of the *foramen magnum*. In the North American Indian this opening was farther back than in the negro, while some crania from Kauai presented this opening still farther back than in the

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[1] "Proceedings of the Boston Society of Natural History," vol. x., p. 185.

[2] Ibid., vol. ix., p. 352.

[3] Ibid., vol. xi., p. 447.

Indian; and more than half the lot from Kauai had the peculiarity in the nostrils first pointed out in the negro by Dr. John Neil, of Philadelphia, namely, the deficiency of the sharp ridge which forms the lower border of the opening. In its place is a rounded border, or an inclined plane.

This feature occurs very frequently in different races, but more rarely in Europeans. It is, however, never absent in the apes. Prof. Wyman, in studying the characters of certain ancient crania from a burial-place near Shell Mound, Florida, observed the *foramen magnum* quite far back, and remarks on the massive character of the bones composing the skull, the parietal being nearly twice the thickness of ordinary parietals, while the general roughness of the surfaces for muscular attachments on the hinder part of the head is very striking.[1]

In certain measurements of synostotic crania, Prof. Wyman found that the length of the parietals was twenty-four millimetres above the average, the parietals being lengthened from before backward, the frontal and occipital being but slightly augmented. Now, in the much-discussed Neanderthal skull, wherein it is urged by Dr. Davis that it is a synostotic skull, though denied by Huxley, Wyman shows that the parietals measure nine millimetres *below* the average, which is certainly against the view that the Neanderthal skull is synostotic.[2]

In an essay entitled "Observations on Crania and Other Parts of the Skeleton," Prof. Wyman shows that the relative capacity of the skull "is to be considered merely as an anatomical and not as a physiological characteristic,"[3] a most important distinction certainly in considering the large capacity of certain ancient skulls, since we must know the quality as well as the quantity in order to assume the intellectual position of the races. In this essay are also quoted the results of a large series of measurements made by Dr. B. A. Gould, in which it is shown that the arms of the blacks are relatively longer as compared with the whites, in this respect approaching the higher animals, a confirmation of the observations made by Broca, Pruner Bey, Lawrence, and others.

The perforation of the humerus, which occurs in the apes quite generally, was found to occur rarely in the white race. Of fifty humeri, Wyman found but two perforated, while of Indian humeri he found thirty-one per cent. perforated. In some of the remains of ancient men there has been found a remarkable lateral flattening of the tibia, unlike anything found at present, but always characteristic of the earliest races. These tibiæ have received the name of platycnemic tibiæ.

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[1] "Fourth Annual Report of the Peabody Archæological Museum. Cambridge."

[2] "Proceedings of the Boston Society of Natural History," vol. xi., p. 455.

[3] "Fourth Annual Report of the Peabody Archæological Museum."

Wyman[1] quotes Broca as saying that the measurements of these tibiæ resemble the ape, and, what is more striking, in a small number of instances "the bone is bent and is strongly convex forward, and its angles so rounded as to present the nearly oval section seen in the apes." The occurrence of these platycnemic tibiæ has been noticed by several investigators. They have been obtained from the mounds of Kentucky by Mr. Carr, Mr. Lyon, and Prof. Putnam. Prof. Wyman found them in Florida mounds. To Mr. Henry Gillman, of Detroit, science is indebted for the discovery of the flattest tibiæ ever recorded, exceeding even those discovered in Europe. Mr. Gillman has opened a number of mounds along the Detroit and Rouge Rivers in Michigan, and assiduously studied the characters of these remains, which indicate a very ancient race of men. Many of these tibiæ he has sent to the Peabody Archæological Museum at Cambridge. Associated with these remarkable tibiæ he found large numbers of perforated humeri.

At the Detroit meeting of the Association, Prof. W. S. Barnard showed that the muscles which move the fingers and toes have been developed from one common muscle, and, in studying the various degrees of specialization of the muscles which move the hand and foot in the gorilla and lower apes, he finds that in the foot "man remains a creature of the past not modified by that which makes him a man, the brain. The hand has been modified and perfected by its services to the brain." Prof. Barnard also contributed another essay, entitled "Comparative Myology of Man and the Apes." From very careful studies he is led to believe that the relative position of the origin of the muscles is more constant than that of their insertions. In this examination he brings to light a muscle which Traill dissected in the higher apes, and which he called the *scansorius*, and this was supposed to have no representative in man.

Traill was followed by Wyman, Owen, Wilder, and Bischoff, who, in a controversy with Huxley, argued from this muscle against the simian origin of man. Mr. Barnard now shows that Traill was mistaken, and that other naturalists were misled by the weight of his authority. What Traill interpreted as the *gluteus minimus* is the *pyriformis*, and what he figured as a new muscle separating the apes from man, the *scansorius*, is the *homologue* of our *gluteus minimus*.

From gradually accumulating data, in regard to microcephalic skulls, it would seem as if Carl Vogt were right in judging them to be cases of reversion. Prof. Wyman says, in regard to a microcephalic skull from Mauritius, that, "taking together the high temporal ridges, the union of the temporals with the frontals, the projection of the jaws, the narrow and retreating forehead, the small capacity, and the form and proportions of the nasal openings, the general resemblance to that of an ape is most striking, and seems to justify Vogt's expression of a man-ape, it being understood that the skull we are describing is not a natural, but an anomalous formation."[1]

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[1] "Fourth Annual Report of the Peabody Archæological Museum."

It would be difficult to imagine, indeed, that mere reduction in the size of the brain, through arrest of development, should produce a series of characters so closely resembling the apes as is found to be the case in so many widely-separated examples. Thus, in the Mauritius microcephalic skull the capacity is only twenty-five cubic inches. The jaws are extremely prognathous, the zygomatic arches stand out wide and free, and the temporal ridges approach within one and a quarter inch. If such examples should prove to be veritable cases of reversion, then we have a parallel in the startling appearance of the long-lost rudimentary toes of the horse, traces of which are only seen in the hidden splint-bones. In the "Seventh Annual Report of the Archæological Museum," Prof. Wyman describes a microcephalic skull from the ancient *huacals* of Peru. Its capacity is only thirty-three cubic inches; "the frontal bone is much slanted backward, has a decided ridge corresponding to the frontal suture, and is slightly concave on each side of it."

Wyman states that the bones of the head are well formed, though, from the diminutive size of the brain, idiocy must have existed.

Associated with the remarkable collection of platycnemic tibiæ and perforated humeri discovered by Mr. Henry Gillman, we should have expected some anomalous forms of crania, and in this expectation we are not disappointed.

In company with two skulls which appear to be normal, Mr. Gillman discovered one of most remarkable proportions. Wyman considers it a case of extreme individual variation, and not the result of artificial deformity. The skull in question has only a capacity of fifty-six cubic inches. The average capacity of Indian crania, according to Morton's measurements, being eighty-four cubic inches, and the minimum capacity being sixty-nine cubic inches, the skull of Gillman is therefore thirteen cubic inches less than the smallest Indian skull heretofore described. But more extraordinary still is the approximation of the temporal ridges. While in ordinary crania the separation of these ridges is usually from three to four inches, and never less than two inches, in this unique skull from the Detroit River mound the ridges in question approach within three-quarters of an inch, in this respect, as Wyman says, presenting the same condition as that of the chimpanzee. A rounded median crest can be distinctly seen and felt between these ridges, and the skull is markedly depressed on each side for the passage of the powerful mastoid muscles.

Is this, too, a case of partial reversion? Such extraordinary forms as the Neanderthal and Engis skulls, and the one above cited, with the La Naulette and other lower jaws, could not have been uncommon in those early days, since the chances against finding them would be simply enormous, unless, indeed, they were of common occurrence. Looking at these remains as at the remains of other mammals, we must admit either that these low characters represent retention of ancestral peculiarities, or that they are cases of reversion. In considering the Neanderthal skull, with its retreating frontal, its enormous frontal crest, and other anthropoid characters, Huxley is led to say that at most there is "demonstrated the existence of a man whose skull may be said to revert somewhat toward the pithecoid type."

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[1] "Seventh Annual Report of the Peabody Archæological Museum."

To a mind unbiased by preconceived opinions, and frankly willing to interpret the facts as they stand revealed by the study of these ancient remains the world over, the evidence of man's lowly origin seems, indeed, overwhelming.

Looking at the whole question impartially, we find that among recent men there are high types as well as low types, with a variation so great as to have induced Agassiz, Morton, and others, to consider them specific. And while, as Wyman asserts, no one race possesses all the low characters, yet with the relatively long arms, the tendency of the pelvis to depart from the normal proportion, and numerous other facts of like significance, there are yet retained among some of them more resemblances to the higher apes than can be found among others.

Prof. Cope, not content with tracing man back to some ape-like progenitor, has, in a suggestive way, considered man's relations to the Tertiary mammalia. In a communication to the Association at Detroit, on this subject, he prefaced his paper by saying that in the doctrine of evolution two propositions must be established: 1. That a relation of orderly succession of structure exists, which corresponds with a succession in time; 2. That the terms (species, genera, etc.) of this succession actually display transitions or connections by intermediate forms, whether observed to arise in descent, or to be of such varietal character as to admit of no other explanation of their origin." He shows that the primary forms of mammalia are strongly indicated in the structure of the feet, and also in the character of the teeth. In recent land-mammals there are several types of foot to be recognized, the many-toed plantigrade, the carnivorous, the ox, and the horse types. Among the earlier types of the Eocene, he finds the most generalized type in the Coryphodon of Owen (Bathmodon of Cope). This creature was plantigrade, with a short calcaneum, and an imperfect hinge for the foot. From this generalized form he traces a line of succession of intermediate forms to the horse on the one hand, and the ox on the other.

The Coryphodon was one of the earliest known mammals, while the horse and the ox preceded man by a single geological period. Without entering into a technical description of the successive forms presented by Prof. Cope, we may quote his words wherein he shows that "the mammals of the Lower Eocene exhibit a greater percentage of types that walk on the soles of their feet, while the successive periods exhibit an increasing number of those that walk on the toes; while the hoofed animals and Carnivora of recent times nearly all have the heel high in the air, the principal exceptions being the elephant and bear families." After presenting the gradual osteological changes of the foot, from the earlier types to the later ones, through several lines of descent, considering also the teeth as well, he says: "The relation of man to this history is highly interesting. Thus, in all generalized points, his limbs are those of the primitive type, so common in the Eocene. He is plantigrade, has five toes, separated tarsals and carpals, short heel, rather flat astragalus, and neither hoofs nor claws, but something between the two; the bones of the forearm and leg are not so unequal as in the higher types, and remain entirely distinct from each other, and the ankle-joint is not so perfect as in many of them. In his teeth his character is thoroughly primitive. . . .

"His structural superiority consists solely in the complexity and size of his brain. A very important lesson is derived from these and kindred facts. The monkeys were anticipated in the greater fields of the world's activity by more powerful rivals. The ancestors of the ungulates held the fields and the swamps, and the Carnivora, driven by hunger, learned the arts and cruelties of the chase. The weaker ancestors of the Quadrumana possessed neither speed nor weapons of offense and defense, and nothing but an arboreal life was left them, where they developed the prehensile powers of the feet. Their digestive system unspecialized, their food various, their life the price of ceaseless vigilance, no wonder that their inquisitiveness and wakefulness were stimulated and developed, which is the condition of progressive intelligence"—adding that "the race has not been to the swift, nor the battle to the strong." Prof. Cope shows in this case that "the survival of the fittest has been the survival of the most intelligent, and natural selection proves to be, in its highest animal phase, intelligent selection."

Prof. Fiske has in a clearer way shown that when variations in intelligence became more important than variations in physical structure, then they were seized upon, to the relative exclusion of the latter.

It is intelligent strength, other things being equal, that conquers the savage, and the gradual selection of the best and biggest brains is not seen alone in man.

In one of the most significant discoveries of Prof. Marsh, the mammalia are found to show an increase in the size of the brain coincident with their succession in the rocks.

One of the most extraordinary mammals from the Tertiary beds of the West is the Dinoceras, with its rhinoceros and elephant characters, its skull ornamented with prominent tubercles, its unique dentition, embracing large cutting tusks, and altogether forming a beast like the fabled monsters of old.

A study of its cranial cavity, made by Prof. Marsh, shows that its brain was proportionally smaller than that of any known mammal. Indeed, it was almost reptilian, and of such diminutive size that it could have been drawn through the neural canal of all the presacral vertebræ. Prof. Marsh has followed up this discovery with the most important results, and is now prepared to state the following conclusions:

1. That all the Tertiary mammals had small brains.
2. There is an increase in the size of the brain during this period.
3. This increase was mainly confined to the cerebral hemispheres or higher portion of the brain.
4. In some groups the convolutions of the brain have gradually become more complicated.
5. In some the cerebellum and olfactory lobes have even diminished in size.

He also finds some evidence that the same general law holds good for birds and reptiles from the Cretaceous to the present time.[1]

Thus we have in other groups as well as man convincing proof that, with successive survival of forms, there is a corresponding survival of larger brains.

Prof. Shaler[2] has offered some suggestive thoughts in showing the intense selective action which must have taken place in the shape and character of the pelvis in man, on his assumption of the erect position—the caudal vertebræ turning inward; the lower portion of the pelvis drawing together to hold the viscera, which had before rested on the elastic abdominal walls; the attending difficulties of parturition, and other troubles in those parts—all pointing to the change which has taken place.

In this connection Prof. Shaler remarks that the question of labor in woman must not be overlooked from this standpoint.

In a memoir on the shell-heaps of Florida, by Prof. Wyman, wherein he describes a number of low characters in man already alluded to, he gives the following conclusions: "The steady progress of discovery justifies the inference that man in the earlier periods of his existence, of which we have any knowledge, was at most a savage, enjoying the advantage of a few rude inventions. According to the theory of evolution, which has the merit of being based upon, and not inconsistent with, the observed analogies and processes of Nature, he must have gone through a period, when he was passing out of the animal into the human state, when he was not yet provided with tools of any sort, and when he lived the life of a brute."[3]

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[1] *American Journal of Science*, vol. xii., July, 1876.

[2] "Proceedings of the Boston Society of Natural History," vol. xv., p. 188.

[3] "Memoirs of the Peabody Academy of Sciences," vol. i., part iv.

These words have no obscure significance, and when we regard the character of the one who wrote them, his cautious methods of research, and the long deliberation he was wont to give to all such questions, then they become doubly important.

Recognizing clearly the existence of these lower and earlier stages in man, it has been one of the most difficult problems to solve the first steps toward his society and family relations. Prof. John Fiske, in his "Outlines of Cosmic Philosophy," has given for the first time a rational explanation of the origin and persistence of family relations, and thence communal relations, and, finally, society.

Never before has there been presented so clear an idea of man's physical changes, and the effects of natural selection in seizing upon attendant or correlated nervous changes, as in the work of this author.

Prof. Fiske says: "Civilization originated when in the highest mammals variations in intelligence became so much more important than variations in physical structure that they began to be seized upon by natural selection, to the relative exclusion of the latter."[1]

Starting from the researches of Sir Henry Maine, Lubbock, and others, he finds social evolution must have originated after families temporarily organized among the higher mammals had become permanently organized. But how this step was effected has been an insoluble problem. Bagehot, in his remarkable work on "Physics and Politics," says: "It is almost beyond imagination how man, as we know man, could by any sort of process have gained this step in civilization." Darwin supposes that men were originally weak and inoffensive creatures, like the chimpanzee, and were compelled to band together to make up in combined strength what they lacked as individuals.

That man, for his age, is a weak animal physically, there can be no doubt. Fiske shows that "increase of intelligence in complexity and specialty involves a lengthening of the period during which the nervous connections involved in ordinary adjustments are becoming organized." From these conditions arose the phenomena of infancy, and he shows that with increase of intelligence infancy becomes longer. In the human race it is longer than in any other mammal, and much longer in civilized man than in the savage.

In the orang-outang the infant does not begin to walk till it is a month old, and in performing this act it holds to various objects for support, as in the human infant. Previous to that time it reposes on its back, and becomes absorbed in gazing at its hands and feet. Now, still lower down among the monkeys, at the age of one month the young are fully matured so far as walking and prehension are concerned. It is shown, furthermore, that where infancy is very short, parental feeling may be intense for a while, but soon dies out, and the offspring of one becomes of no greater interest than those of a stranger, "and in general the duration of the feelings which insure the protection of the offspring is determined by the duration of the infancy. . . .

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[1] "Cosmic Philosophy," vol. ii., p. 340.

"Hence if long infancies could have suddenly come into existence among a primitive race of ape-like men, the race would have quickly perished from inadequate persistence of parental affection." Prof. Fiske, in a most reasonable way, shows that "the prolonged helplessness of the offspring must keep the parents together for longer and longer periods in successive epochs; and when at last the association is so long kept up that the older children are growing mature while the younger ones still need protection, the family relations begin to become permanent. The parents have lived so long in company that to seek new companionships involves some disturbance of ingrained habits, and meanwhile the older sons are more likely to continue their original association with each other than to establish associations with strangers, since they have common objects to achieve, and common enmities bequeathed, inherited or acquired with neighboring families."

In his chapter on the moral genesis of man Fiske maintains that "the prolongation of human infancy accompanying the development of intelligence, and the correlative extension of parental feeling, are facts established by observation wherever observation is possible; and to maintain that the correlation of these phenomena was kept up during an epoch which is hidden from observation, and can only be known by inference, is to make a genuine induction, involving no other assumption than that the operations of Nature are uniform. To him who is still capable of believing that the human race was created by miracle in a single day, with all its attributes, physical and psychical, compounded and proportioned, just as they now are, the present inquiry is of course devoid of significance. But for the evolutionist there would seem to be no alternative but to accept, when once propounded, the present series of inferences."

Recalling now the various evidences educed by Wyman, Giman, and others, regarding the anomalous characters of the remains of primitive man, it seems impossible that a mind unbiased by preconceived opinion should be able to resist the conviction as to man's lowly origin.

If we take into account the rapidly-accumulating data of European naturalists concerning primitive man, with the mass of evidence received in these notes, we find an array of facts which irresistibly point to a common origin with animals directly below us, and these evidences are found in the massive skulls with coarse ridges for muscular attachments, the rounding of the base of the nostrils, the early ossification of the nasal bones, the small cranial capacity in certain forms, the prominence of the frontal crest, the posterior position of the *foramen magnum*, the approximation of the temporal ridges, the lateral flattening of the tibia, the perforation of the humerus, the tendency of the pelvis to depart from its usual proportions, and, associated with all these, a rudeness of culture and the evidence of the manifestation of the coarsest instincts. He must be blind indeed who cannot recognize the bearing of such grave and suggestive modifications. But what application are we to make of such revelations if we vividly receive them as such? We are no longer to rest with the blind fatalism of the Turks, or listless resignation of the masses, but are to make a living use of them. We are to trace evil and corrupt passions to their source. The dreadful outrages which shock us from time to time in the public prints are not instigated by an evil spirit, but are outbursts of the same savage nature which found more frequent expression years ago, and which are still present with the lower races of to-day. When the study of heredity reveals the fact that even the nature of vagabondage is perpetuated; when the surprising revelations of Margaret, mother of criminals, from whose loins nearly a thousand criminals have thus far been traced, are considered, common-sense will ultimately recognize that the imprisonment of a criminal for ten or twenty years is not simply to punish him or relieve the public of his lawless acts, but to restrain him from perpetuating his kind. No sudden revulsion of feelings and amended ways is to purify the criminal taint, but he is to be quarantined in just the same way that a case of the plague might be, that his kind may not increase. With these plain facts thoroughly understood, men high in authority must find some other excuse for the exercise of their pardoning power, and other reasons be given for allowing so large a proportion of criminals to go free. With the monstrous blot of Mormonism and free-love in our country, the statute-books are to be again revised from the standpoint of science, with its rigid moral and physical laws, and not from the basis of established usage or long-continued recognition.

THE LAWS OF HEALTH.

By THOMAS BOND, F. R. C. S.

ON an average, one-half of the number of out-patients treated by a hospital-surgeon suffer from diseases due primarily to a want of knowledge of the laws of health and cleanliness. 1. The ignorance of hygienic laws, which affects so disastrously the health of the rich as well as the poor, exists chiefly in regard to dress, ablution, and ventilation. This statement may, at first, appear startling, but an enumeration of the diseases that can be constantly traced to the above causes will show upon how sound a basis the statement rests. The following are examples: Varicose ulcers from dress; skin-diseases from want of cleanliness; chest-diseases and fevers from defective ventilation. The vast number of ulcerated legs treated in the out-patient department of hospitals, in workhouse infirmaries, and in private practice, arise from varicose veins. Now, a varicose ulcer is caused by a distended condition of the veins of the leg, which have to sustain the pressure of the blood caused by gravitation. In varicose veins, the valves which help to support the column of blood are to a great extent destroyed, through the veins having been distended by mechanical obstruction to the free return of the blood from the extremities, thereby distending the lower veins and separating the edges of the valves. Thus, the weight of an uninterrupted column has to be borne by the veins. This, of course, causes further distention, giving rise to congestion of the capillaries of the skin, and causing swelling, eczema, and ultimately ulceration. This is the varicose ulcer so common in the laboring-classes. It is always difficult to heal, and often impossible, except by prolonged rest in bed. Hence it is the dread of the surgeon, and the cause of misery to thousands. Varicose ulcers are seldom admitted into general hospitals, so that hundreds of poor families are driven to the workhouse, and such cases form a majority in the workhouse infirmary. The most frequent and flagrant cause of obstruction is the ordinary elastic garter. Children should never wear them at all, as the stockings can be perfectly well kept up by attachment of elastic straps to the waistband. If garters are worn, it is important to know how to apply them with the least risk of harm; at the bend of the knee the superficial veins of the leg unite, and go deeply into the under part of the thigh beneath the ham-string tendons. Thus a ligature below the knee obstructs all the superficial veins, but if the constriction is above, the ham-string tendons keep the pressure off the veins which return the blood from the legs; unfortunately, most people, in ignorance of the above facts, apply the garter below the knee. Again, in nine out of ten laboring-men, we find a piece of cord or a buckled strap tightly applied below the knee, for what reason I could never learn. Elastic bands are the most injurious. They follow the movements of the muscles, and never relax their pressure on the veins. Non-elastic bands during muscular exertion become considerably relaxed at intervals, and allow a freer circulation of the blood.

2. The habit of tight lacing again predisposes to varicose veins, in consequence of the abdominal viscera being pushed downward into the pelvis, causing undue pressure on the veins of the lower extremities when they enter the pelvis. Physicians also have reported numerous cases of heart and lung disease caused by this pernicious habit.

3. The use of dress is often misunderstood. Most persons evidently study and practise it with regard to appearance, or only to keep out wet and cold. The hygienic use of clothes, however, is not so much

to keep cold out as to keep heat in. The mistake is often made, of taking great care to put on extra wraps and coats when preparing for out-door exercise. This is not at all necessary in robust persons. Sufficient heat to prevent all risk of chill is generated in the body by exercise. The care should be taken to retain sufficient clothing after exercise, and when at rest, to prevent the heat passing out of the body. Indeed, persons very often catch chills from throwing off extra clothing after exercise, or from sitting about in garments, the material of which is not adapted to prevent the radiation of heat from the body. Linen and cotton under-clothing, when moistened by perspiration, parts with heat very rapidly, whereas flannel and silk, being non-conductors, prevent the rapid loss of heat.

4. The most recent offense against the laws of health is the habit of wearing false hair. The perspiration of the scalp is prevented, by the thick covering, from evaporating, thereby causing a sodden and weakened condition of the skin, which predisposes to baldness and other diseases of the scalp. Again, it produces headache and confusion of the intellectual faculties. We all know what a relief it is, during hard mental work, simply to raise one's hair by running the fingers through it. I should think literary ladies either do not wear false hair, or take it off when at work.

5. Ablution is another subject of paramount importance to health. Mr. Urquhart, the introducer of the Turkish bath into this country, is one of the benefactors of the age, and it is to be hoped some day there will be a bath in every town and village in England. Doctors are very much to be blamed for allowing themselves to be prejudiced against it. The usual opinion given by medical men to their patients is, that it is debilitating, and only to be borne by the robust. The reverse is really the case: it is stimulating and strengthening, it is a preventive as well as curative in disease. The effect of the Turkish bath on the skin is to cause an active condition of its functions of elimination, by removing the hardened epithelial scales, by removing the fat from the pores, and by causing the sweat-glands to maintain the activity of their functions, giving a general stimulus to the vital power of the skin. Again, it keeps the body in a state of perfect cleanliness, which is so essential to robust health; but these are not its only virtues—it promotes purity of mind and morals. The man who is accustomed to be physically clean shrinks instinctively from all contact with uncleanliness.

6. There are, however, certain precautions to be observed in the use of the baths. Persons who are apoplectic, or suffering from fatty degeneration of heart, should not venture to disturb the circulation by the excitement of baths. The first effect of Turkish baths is to stimulate the circulation, the second to cause active congestion of the skin, the third to produce profuse perspiration, the fourth to keep down the temperature of the body by rapid evaporation. On leaving the

Turkish bath the body should be douched with cold water; the capillaries are thus emptied of their blood by contraction, but immediately after the stimulation causes them to resume a state of activity, and produces vigorous circulation through the skin.

7. In taking a cold bath in the morning the same conditions should be present. The surface of the body should be warm and moist; therefore, the bath should be taken immediately on rising from the bed, and before the surface of the body has had time to cool or the capillaries to contract. The shock of the cold water should cause them suddenly to contract; then quick reaction will take place in the same way as after a Turkish bath. Unless this reaction occurs after the bath, there is great danger of getting a chill; at any rate, the full benefit of the bath is not obtained. Persons with weak circulation, who cannot take an ordinary morning bath, often derive great benefit from the Turkish bath. It opens the pores and improves the circulation of the skin, so that the shock of cold water can afterward be borne. The same persons can generally bear a cold bath if they get for a few minutes into a warm bath first, and then immediately plunge into cold water. By these means an active reaction is brought about. Warm baths should, in my opinion, never be taken on rising except under the above conditions, but warm baths at night are often desirable. They should be taken just before going to bed, when they have the effect of relaxing the muscular system and of promoting sleep by soothing the activity of the brain by the withdrawal of blood from it. I do not think warm baths at night are weakening, as the depression of vital energy which may occur is recovered during sleep. In river and sea bathing, persons should be careful not to remain in the water too long, nor should they exert themselves sufficiently to cause exhaustion, as the power of reaction is much impaired thereby; neither should persons get into cold water when cooling. The old-fashioned idea that persons should wait to cool before plunging into the water is a fallacy. There is no danger in plunging into the coldest water in a state of profuse perspiration, if the heart and arteries are in a healthy state. Of course, it would be unwise to do so immediately after a full meal, as the action of the heart might be impeded by the distended stomach.

8. Many persons complain of always getting up tired in the morning. This is very often due to defective ventilation of the bedroom, or from using an undue amount of bedclothes and bedding. Feather beds are too soft and yielding, and partially envelop the sleeper, thus producing profuse perspirations. The habit of lying too much under blankets is also very pernicious, by reason of the carbonic acid exhaled by the sleeper being respired. Again, it is a common error to suppose that, by simply opening a window a little at the top, a room can be ventilated. People forget that for proper ventilation there must be an inlet and outlet for the air. In bedrooms there is often

neither, and if there is a fireplace it is generally closed up. Again, it is a mistake to suppose that foul air goes to the top of a room. Certainly the heated air goes to the top, but the chief impurity, the carbonic acid, falls to the bottom. There is nothing so efficacious in removing the lower strata of air as the ordinary open fireplace, especially if there is a fire burning. The usual defect in ventilation is the want of a proper inlet for the air. If the window be open, the cold air, being heavier, pours down into the room, causing draughts; if the door be open or ajar, the same thing occurs. The perfection of ventilation may be obtained in any room with a fireplace by simply providing proper inlets for the air, and nothing answers so well for the purpose as the upright tubes invented by Mr. Tobin. By this means the heavier external atmosphere ascends vertically through the tubes like the jet of a fountain, displacing the warmer and lighter atmosphere of the room, which finds its exit up the chimney. The tubes should communicate with the outer air on a level with the floor, and should be carried vertically upward in the room for about four or five feet. A constant supply of fresh air is thus insured without the slightest liability to draught, as the current goes directly upward until it strikes the ceiling. It is then diffused downward, mixed with the heated air of the ceiling. The same principle can be carried out in any room with a sash-window, by cutting out two or three holes an inch wide and three inches long in the wood-work of the upper sash where it joins the lower one. The columns of air ascend directly upward, just inside the window, and mix with the heated air in the upper part of the room. If this system were universally carried out, we should hear less of rheumatism and chills caught by sitting in draughts.

9. Persons should cultivate the faculty of detecting sewer-gas in houses. Typhoid fever is often caused by the escape of this gas into the house through defect of the traps and drains. However bad the drains may be outside of the house, there is little to fear, provided the gas can escape externally. The following two very simple precautions would naturally diminish the cases of typhoid fever: First, every main drain should have a ventilating-pipe carried from it, directly outside of the house, to the top of the highest chimney; secondly, the soil-pipe inside the house should be carried up through the roof, and be open at the top.—*English Mechanic.*

CANINE SAGACITY.

A CORRESPONDENT hands us the following anecdotes illustrative of the remarkable reasoning powers of dogs:

The first case is one which occurred at a fashionable watering-place on the east coast of Ireland, some twenty years ago, and exhibits the remarkable sagacity displayed by a dog in carrying out the dictates of the animal passion for revenge. The jetty which stretched along the small harbor was at that time used as a promenade by the *élite* among the sojourners on the coast, where, after the heat of the long summer days, they regaled themselves with the fresh evening breezes wafted in from the sea. Among the frequenters of this fashionable resort was a gentleman of some position, who was the owner of a fine Newfoundland dog, which inherited the time-honored possessions of that noble breed—very great power and facility in swimming; and, at the period of the evening when the jetty was most crowded with promenaders, his master delighted to put this animal through a series of aquatic performances for the entertainment of the assembled spectators. Amusement being at a premium on the coast, these nightly performances grew into something like an "institution," and the brave "Captain"—for such was his name—speedily became a universal favorite on the jetty. It happened, however, that among the new arrivals on the coast there came a certain major in her majesty's army, accompanied by two bull-dogs of unusual size and strength, and of great value; but, value in a bull-dog being inversely proportionate to its beauty, the appearance of the major and his dogs excited no very enthusiastic pleasure among the æsthetic strollers on the jetty. On the first night on which the major presented himself, nothing unusual occurred; and Captain dived and swam as before. But on the second evening the brave old favorite was walking quietly behind his master down the jetty, when, as they were passing by the major and his dogs, one of these ugly brutes flew at Captain, and caught him by the neck in such a way as to render his great size utterly useless for his defense. A violent struggle ensued, but the bull-dog came off the victor, for he stuck to his foe like a leech, and could only be forced to release his hold by the insertion of a bar of iron between his teeth. The indignation of the by-standers against the major was, of course, very great; and its fervor was not a little increased when they saw the poor Captain wending his way homeward, bleeding, and bearing all the marks of defeat. Some two or three evenings after this occurrence, when Captain again made his appearance on the jetty, he looked quite crestfallen, bore his tail between his legs, and stuck closely to the heels of his master. That evening passed away quietly, and the next, and the next, and so on for about a week—Captain still bearing the aspect of mourning. But one evening about eight or ten days after the above encounter, as the major was marching in his usual pompous manner along the jetty, accompanied by his dogs, something attracted his attention in the water, and, walking to the very edge of the jetty, he stood for a moment looking down into the sea. Scarcely had the two bull-dogs taken up their stand beside their master when Captain, seizing the opportunity for which he had so long looked, rushed at his former conqueror, and, catching him by the back of the neck, jumped off the jetty, with his foe in his mouth, down some twenty feet or more into the sea. Once in the water, the power of his enemy was crippled, while Captain was altogether in his own element; and, easily overcoming all efforts at resistance, he succeeded in resolutely keeping the bull-dog's head under water. The excitement on the shore was, of course, intense. The major shouted, and called out: "My dog! my beautiful dog! Will no one save him?" But no one seemed at all inclined to interfere, or to risk his life for the ugly dog. At length the major called out: "I'll give fifty pounds to any one who will save my dog;" and soon afterward a boat which lay at some little distance pulled up to the rescue. Even then, however, it was only by striking Captain on the head with the oars that he could be forced to release his victim, which was taken into the boat quite senseless from exhaustion and suffocation, and was with difficulty brought to itself again. Captain, on the other hand, swam in triumph to the shore, amid the plaudits of the spectators, who shared, in sympathy at least, his well-earned honors of revenge.

More remarkable than the sagacity in carrying out the desire for revenge, displayed by the Newfoundland dog in the above case, is that which the following narrative illustrates: A gentleman of wealth and position in London had, some years ago, a country-house and farm about sixty miles from the metropolis. At this country residence he kept a number of dogs, and among them a very large mastiff and a Scotch terrier; and, at the close of one of his summer residences in the country, he resolved to bring this terrier with him to London for the winter season. There being no railway to that particular part of the country, the dog traveled with the servants in a post-carriage, and on his arrival at the town-house was brought out to the stable, where a large Newfoundland dog was kept as a watch-dog. This latter individual looked with anything but pleasure on the arrival of the little intruder from the country; and consequently the Scotch terrier had not been very long in his new home when this canine master of the stable attacked him, and, in the language of human beings, gave him a sound thrashing. The little animal could, of course, never hope by himself to chastise his host for this inhospitable welcome, but he determined that by some agency chastisement should come. Accordingly, he lay very quiet that night in a remote corner of the stable, but when morning had fully shone forth he was nowhere to be found. Search was made for him, as the phrase says, high and low, but without success; and the conclusion reluctantly arrived at was, that he had been stolen. On the third morning after his disappearance, however, he again showed himself in London, but this time not alone; for, to the amazement of every one, he entered the stable attended by the big mastiff from Kent. This great brute had no sooner arrived than he flew at the Newfoundland dog, who had so badly treated his little terrier friend, and a severe contest ensued, which the little terrier himself, seated at a short distance, viewed with the utmost dignity and satisfaction. The result of the battle was, that the mastiff came off the conqueror, and gave his opponent a tremendous beating. When he had quite satisfied himself as to the result, this great avenger from Kent scarcely waited to receive the recognition of his master, who had been sent for immediately on the dog's arrival, but at once marched out of the stable, to the door of which the little terrier accompanied him, and was seen no more. Some few days afterward, however, the gentleman received a letter from his steward in the country, informing him of the sudden appearance of the terrier there, and his as sudden disappearance along with the large mastiff; and stating that the latter had remained away three or four days, during which they had searched in vain for him, but had just then returned home again. It then, of course, became quite clear that the little dog, finding himself unable to punish the town bully, had thought of his "big brother" in the country, had traveled over the sixty miles which separated them, in order to gain his assistance, and had recounted to him his grievance; it was plain also that the mastiff had consented to come and avenge his old friend, had traveled with him to London, and, having fulfilled his promise, had returned home, leaving the little fellow free from annoyance in the future.

The following well-known story is a strong example of the great intelligence which may be developed in a dog by careful training: A fashionably-dressed English gentleman was one day crossing one of the bridges over the Seine at Paris, when he felt something knock against his legs, and, looking down, he found that a small poodle-dog had rubbed against him, and covered his boots with mud. He was, of course, much annoyed, and execrated the little brute pretty freely; but when he got to the other side of the bridge, he had the boots cleaned at a stand for the purpose, and thought no more about the matter. Some days after this occurrence, however, he had occasion again to cross that bridge, and the same little incident occurred. Thinking this somewhat odd, he resolved to watch where the little dog went to; and, leaning against the side of the bridge, he followed with his eye the movements of his dirty little friend. He saw him rub against the feet of one gentleman after another, till he had exhausted all the mud off his once white skin, then rush off down the bank of the river, and there roll himself in the mud collected at the side. Having thus got a new supply of dirt, the little animal ran up to the bridge again, and proceeded to transfer it to the boots of the passers-by, as before. Having watched his movements for some time, the gentleman noticed that on one occasion, instead of running down to the river, he went off to the proprietor of the stand for cleaning boots, at the other end of the bridge, who received him very cordially. The truth then for the first time dawned on him, that the little animal belonged to the man who cleaned the boots, and was trained by him to perform these mischievous deeds, for the purpose of bringing in custom. Being very fond of dogs, the Englishman resolved to purchase this clever little fellow, and bring him back to England with him. When, however, he went to the dog's master, that person at first denied any connection with him, and only admitted the ownership when he was perfectly satisfied that his interrogator had no connection with the police. For some time also he refused to part with the little poodle, saying that no money could pay him for the loss of his dog, who really made his living for him. Tempted, however, by a very high price, he at last consented to sell the dog; and the gentleman, a few days afterward, brought him over to England, traveling *via* Boulogne to Folkstone. His residence in England was some thirty or forty miles from Folkstone, and to this place he brought his little purchase. He had not been many days in his new home, however, when the little French poodle suddenly disappeared. Search was made for him everywhere, but to no effect. His new master offered a reward for him, but with the same result; and he had at last made up his mind that the little fellow had been either poisoned or stolen, when one morning, about six weeks after his mysterious disappearance, the gentleman received a letter from a friend in Paris telling him that his dog was back again there, and at his old trade of soiling boots in the interest of his former master. The little fellow, not liking the dullness of a country life, had resolved to return to his former home, and had made his way to Folkstone; there, as the gentleman afterward ascertained, he had got on board a steamer going to Boulogne, and from Boulogne had found his way back to Paris.

Of the foregoing three stories, the first two are probably even more remarkable than the last. The last (except as to the dog's finding its way back to Paris) illustrates only the possibility of developing in a dog, by the training of its natural intelligence, an almost human ingenuity. But it is by instilling into the dog the intelligence of a higher being that this skill is engendered. The spring of the intelligence is in the trainer, and it is to attain an object which the higher being, and not the lower, has in view. But in the first two cases the whole process is the dog's; the object to be secured, namely, revenge, is what the dog himself seeks, and the means by which that object is to be attained are devised and carried out by the instinct of the dog. That a dog should harbor revenge is, of course, not a very wonderful fact; but there is a calm reflection and a cool calculation displayed in the first two cases above given, which make them somewhat peculiar. If what we call instinct in these animals embraces powers so very like reason; if they are swayed by the same passions and affections which move us, and they are able to communicate to their fellows the feelings which stir them, and the external circumstances which bring those feelings into play, the border-line between man's mental territory and theirs becomes a little bit indefinite.—*Chambers's Journal.*

PROFESSOR HUXLEY'S LECTURES.[1]

II.

THE NEGATIVE AND FAVORABLE EVIDENCE.

IN my lecture on Monday night I pointed out that there are three hypotheses which may be entertained, and which have been entertained, respecting the past history of life upon the globe. According to the first of these hypotheses, life, such as we now know it, has existed from all eternity upon this earth. We tested that hypothesis by the circumstantial evidence, as I called it, which is furnished by the fossil remains contained in the earth's crust, and we found that it was obviously untenable. I then proceeded to consider the second hypothesis, which I termed the Miltonic hypothesis, not because it is of any particular consequence to me whether John Milton seriously entertained it or not, but because it is stated in a clear and unmistakable manner in his great poem. I pointed out to you that the evidence at our command as completely and fully negatives that hypothesis as it did the preceding one. And I confess that I had too much respect for your intelligence to think it necessary to add that that negation was equally strong and equally valid whatever the source from which that hypothesis might be derived, or whatever the authority by which it might be supported.

I further stated that, according to the hypothesis of evolution, the existing state of things was the last term of a long series of antecedent states, which, when traced back, would be found to show no interruption and no breach of continuity. I propose in this and a following lecture to test this hypothesis rigorously by the evidence at command, and to inquire how far that evidence could be said to be indifferent to it, how far it could be said to be favorable to it, and, finally, how far it could be said to be demonstrative. From almost the origin of these discussions upon the existing condition—and the causes which have led to it—of the animal and vegetable worlds, an argument has been put forward as an objection to evolution, which we shall have to consider very seriously. I think that that argument was first clearly stated by Cuvier in his criticism of the doctrines propounded by his great contemporary, Lamarck. At that time the French expedition to Egypt had called the attention of learned men to the wonderful stores of antiquities in that country, and there had been brought back to France numerous mummified corpses of animals which the ancient Egyptians revered and preserved, the date of which, at a reasonable computation, cannot be placed at less than 3,000 or 4,000 years before the time at which they were thus brought to light. Cuvier endeavored to ascertain, by a very just and proper method, what foundation there was for the belief in a gradual and progressive change of animals, by comparing the skeletons and all accessible parts of these animals, such as crocodiles, birds, dogs, cats, and the like, with those which are now found living in Egypt, and he came to the conclusion —a conclusion which has been verified by all subsequent research— that no appreciable change had taken place in the animals which inhabited Egypt. And he drew thence the conclusion, and a hasty one, that this fact was altogether opposed to the doctrine of evolution. The progress of research since Cuvier's time has furnished far stronger arguments than those which he drew from the mummified bodies of Egyptian animals. A remarkable case is to be found in your own country in the neighborhood of the magnificent falls of Niagara. In the immediate vicinity of the whirlpool, and again upon Goat Island, in the superficial deposits which cover the surface of the soil of the rock in those regions, there are found remains of animals in perfect preservation—shells belonging to exactly the same forms as at present inhabit the still waters of Lake Erie. It is evident from the formation of the country that these animal remains were deposited in the beds in which they occur, at the time at which the lake extended over the region in which they are found. This involves the necessity that they lived and died before the falls had cut their way back through the gorge of Niagara; and, indeed, it is possible to determine that at that time the falls of Niagara must have been at least six miles farther down the river than they are at present. Many computations have been made of the rate at which Niagara is thus cutting its way back. Those computations have varied greatly, but I believe I am speaking within the bounds of prudence if I assume that the falls of Niagara have not retreated at a greater pace than about a foot a year. Six miles, speaking roughly, are 30,000 feet; 30,000 feet, at a foot a year, are 30,000 years; and we are fairly justified in concluding that no less a period than this has passed since these shell-fish, whose remains are left in the beds to which we have referred, were deposited. But there is even still stronger evidence of the long duration of certain types than this. As we work our way through the great series of the Tertiary formations, we find species of animals identical with those which live at the present day, diminishing in numbers, it is true, but still existing in a certain number in the oldest of the Tertiary rocks. And not only so, but when we examine the rocks of the Cretaceous epoch itself, we find the remains of some animals which the closest scrutiny cannot show to be in any respect different from those which live at the present time. That is the case with one of the lamp-shells, a *Terebratula* which is found in the chalk, and which has continued as it was found, or with insignificant variation, through to the present day. Such is the case with the *Globigerinæ*, the skeletons of which, aggregated together, form the great mass of our chalk in England. That *Globigerina* can be traced down to the *Globigerinæ* which live at the surface of our great oceans, and the remains of which, falling to the bottom of the sea, give rise to a chalky material. So that it must be admitted that certain species of creatures living at the present day show no sign of modification or transformation in the course of a lapse of time as great as that which carries us back to the period of chalk. There are groups of species so closely allied together that it needs the eye of a naturalist to distinguish them one from another. If we pay attention to these, we find that a vastly greater period must be allotted, in some cases, to these persistent forms. In the chalk itself, for example, there is the fish belonging to the highest and the most differentiated of osseous fishes, which go by the name of *Beryx*. That fish is one of the most beautiful of fossils found in our English chalk. It can be studied anatomically, so far as the hard parts are concerned, almost as well as if it were a recent fish. We find that that fish is represented at the present day by very closely-allied species which are living in the Pacific and Atlantic Oceans. But we may go still farther back, and we find, as I mentioned to you yesterday, that the Carboniferous formations in Europe and in America contain the remains of scorpions in an admirable state of preservation, and those scorpions are hardly distinguishable from such as now live. I do not mean to say that they are not distinguishable, but they require close scrutiny to distinguish them from the scorpions which exist at the present day.

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[1] The second of three lectures on "The Direct Evidence of Evolution," delivered at Chickering Hall, New York, September 20th. From the report of the *New York Tribune*, carefully revised by Prof. Huxley.

More than that. At the very bottom of the Silurian series, in what is by some authorities termed the Cambrian formation, where all signs of life appear to be dying out—even there, among the few and scanty animal remains which exist, we find species of molluscous animals which are so closely allied to existing forms that at one time they were grouped under the same generic name. I refer to the well-known *Lingula* of the *Lingula* flags, lately, in consequence of some slight differences, placed in the new genus *Lingulella*. Practically it belongs to the same great generic group as the *Lingula*, which you will find at the present day upon the shores of Australia. And the same thing is exemplified if we turn to certain great periods of the earth's history—as, for example, throughout the whole of the Mesozoic period. There are groups of reptiles which begin shortly after the commencement of this period, as the *Ichthyosauria* and the *Plesiosauria*, and they abound in vast numbers. They disappear with the chalk, and throughout the whole of that great series of rocks they present no important modifications. Facts of this kind are undoubtedly fatal to any form of the doctrine of evolution, which necessitates the supposition that there is an intrinsic necessity on the part of animal forms which once come into existence to undergo modification; and they are still more distinctly opposed to any view which should lead to the belief that the modification in different types of animal or vegetable life goes on equally and evenly. The facts, as I have placed them before you, would obviously contradict directly any such form of the hypothesis of evolution as laid down in these two postulates.

Now, the service that has been rendered by Mr. Darwin in the doctrine of evolution in general is this: that he has shown that there are two great factors in the process of evolution: one of them is the tendency to vary, the existence of which may be proved by observation in all living forms; the other is the influence of surrounding conditions upon what I may call the parent form and the variations which are thus evolved from it. The cause of the production of variations is a matter not at all properly understood at present. Whether it depends upon some intricate machinery—if I may use the phrase—of the animal form itself, or whether it arises through the influence of conditions upon that form, is not certain, and the question may for the present be left open. But the important point is the tendency to the production of variations; then, whether the variations which are produced shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on surrounding conditions. If the surrounding conditions are such that the parent form is more competent to deal with them and flourish in them than the derived forms, then, in the struggle for existence, the parent form will maintain itself and the derived forms will be exterminated. But if, on the contrary, the conditions are such as to be better for the derived than for the parent form, the parent form will be extirpated and the derived form will take its place.

In the first case, there will be no progression, no advance of type, through any imaginable series of ages; in the second place, there will be modification and change of form. Thus the existence of these persistent types of life is no obstacle in the way of the theory of evolution at all. Take the case of the scorpions to which I have just referred. No doubt, since the Carboniferous epoch conditions have existed such as existed when the scorpions of that epoch flourished, in which they find themselves better off, more competent to deal with the difficulties in their way than any kind of variation from the scorpion type; and for that reason the scorpion has persisted, and has not been supplanted by any other form. And there is no reason in the nature of things why, as long as this world exists, if there be conditions more favorable to scorpions than any variation which may arise from them, these forms of life should not persist.

Therefore, this objection is no objection at all. The facts of this character—and they are numerous—belong to that class of evidence which I have called indifferent. That is to say, they may afford no direct support to the doctrine of evolution, but they are perfectly capable of being interpreted in consistency with it. There is another order of facts of the same kind, and susceptible of the same interpretation. The great group of *Lizards*, which abound so much at the present day, extends through the whole series of formations as far back as what is called the Permian epoch, which is represented by the strata lying just above the coal. These Permian lizards differ astonishingly little from the lizards which exist at the present day. Comparing the amount of difference between these Permian lizards and the lizards of the present day with the prodigious lapse of time between the Permian epoch and the present age, it may be said that there has been no appreciable change.

But when you carry your researches farther back in time you find no trace whatever of lizards nor of any true reptile whatever in the whole mass of formations beneath the Permian. Now, it is perfectly clear that if our existing paleontological collections, our existing species of stratified rock, exhaust the whole series of events which have ever taken place upon the surface of the globe, such a fact as this directly contravenes the whole theory of evolution, because this theory postulates that the existence of every form must have been preceded by that of some form comparatively little different from it. Here, however, we have to take into consideration that important fact so well insisted upon by Lyell and Darwin—the imperfection of the geological record. It can be demonstrated as a matter of fact that the geological record must be incomplete, that it can only preserve remains found in certain favorable localities and under particular conditions; that it must be destroyed by processes of denudation, and obliterated by processes of metamorphosis—by which I mean that beds of rock of any thickness crammed full of organic remains may yet, either by the percolation of water through them or the influence of subterranean heat (if they descend far enough toward the centre of the earth), lose all trace of these remains, and present the appearance of beds of rock formed under conditions in which there was no trace of living forms. Such metamorphic rocks occur in formations of all ages, and we know with perfect certainty when they do appear that they have contained organic remains, and that those remains have been absolutely obliterated.

I insist upon the defects of the geological record the more because those who have not attended to these matters are apt to say to us, "It is all very well, but, when you get into difficulty with your theory of evolution, you appeal to the incompleteness and the imperfection of the geological record;" and I want to make it perfectly clear to you that that imperfection is a vast fact which must be taken into account in all our speculations, or we shall constantly be going wrong.

You will all see that singular series of tracks which is copied of its natural size in the large diagram hanging up here, which I owe to the kindness of my friend Prof. Marsh, with whom I had the opportunity recently of visiting the precise locality in Massachusetts in which these tracks occur. I am, therefore, able to give you my own testimony, if needed, that they accurately represent the state of things which we saw. The valley of the Connecticut is classical ground for the geologist. It contains great beds of sandstone, covering many square miles, and which present this peculiarity, that they have evidently formed a part of an ancient sea-shore, or, it may be, lake-shore, and that they have been sufficiently soft for a certain period of time to receive the impressions of whatever animals walked over them, and to preserve them afterward in exactly the same way, as such impressions are at this very moment preserved on the shores of the bay of Fundy and elsewhere. We have there the tracks of some gigantic animal (pointing to the diagram), which walked on its hind-legs. You see the series of marks made alternately by the right foot and by the left foot; so that from one impression to the other of the three-toed foot on the same side is one stride, and that stride, as we measured it, is six feet nine inches. I leave you, therefore, to form an impression of the magnitude of the creature which must have walked along the ancient shore, and which made these impressions.

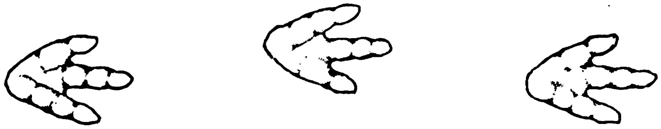

FIG. 1.—TRACKS OF BRONTOZOUM.

Now, of such impressions there are untold thousands upon these shores. Fifty or sixty different kinds have been discovered, and they cover vast areas. But up to this present time not a bone, not a fragment, of any one of the great creatures which certainly made these impressions has been found; and the only skeleton which has been met with in all these deposits to the present day—though they have been carefully hunted over—is one fragmentary skeleton of one of the smaller forms. What has become of all these bones? You see we are not dealing with little creatures, but animals that make a step of six feet nine inches; and their remains must have been left somewhere. The probability is, that they have been dissolved away, and absolutely lost.

I have had occasion to work at series of fossil remains of which there was nothing whatever except the casts of the bones, the solid material of the bone having been dissolved out by percolating water. It was a chance in this case that the sandstone happened to be of such a constitution as to set, and to allow the bones to be afterward dissolved out, leaving cavities of the exact shape of the bones.

Had that constitution been other than what it was, the bones would have been dissolved, the beds of sandstone would have fallen together, become one mass, and not the slightest indication that the animal had existed would have been discovered.

I know of no more striking evidence than this fact affords, of the caution which should be used in drawing the conclusion, from the absence of organic remains in a deposit, that animals did not exist at the time it was formed. I believe that, having the right understanding of the doctrine of evolution on the one hand, and having a just estimation of the importance of the imperfection of the geological record on the other, all difficulty from the kind of evidence to which I have adverted is removed; and we are justified in believing that all such cases are examples of what I have designated negative or indifferent evidence—that is to say, they in no way directly advance the theory of evolution, but they are no obstacle in the way of our belief in the doctrine.

I now pass on to the consideration of those cases which are not—for reasons which I will point out to you by-and-by—demonstrative of the truth of evolution, but which are such as must exist if evolution be true, and which therefore are, upon the whole, strongly in favor of the doctrine. If the doctrine of evolution be true, it follows that, however diverse the different groups of animals and of plants may be, they must have all, at one time or other, been connected by gradational forms; so that, from the highest animals, whatever they may be, down to the lowest speck of gelatinous matter in which life can be manifested, there must be a sure and progressive body of evidence—a series of gradations by which you could pass from one end of the series to the other. Undoubtedly that is a necessary postulate of the doctrine of evolution. But, when we look upon animated Nature as it at present exists, we find something totally different from this. We find that animals and plants fall into groups, the different members of which are pretty closely allied together, but which are separated by great breaks or intervals from other groups. And we cannot at present find any intermediate forms which bridge over these gaps or intervals. To illustrate what I mean: Let me call your attention to those vertebrate animals which are most familiar to you, such as mammals, and birds, and reptiles. At the present day these groups of animals are perfectly well defined from one another. We know of no animal now living which in any sense is intermediate between the mammal and the bird, or between the bird and reptile; but, on the contrary, there are actually some very distinct and anatomical peculiarities, well-defined marks, by which the mammal is separated from the bird, and the bird from the reptile. The distinctions are apparent and striking if you compare the definitions of these great groups as they now exist. At the present day there are numerous forms of what we may call broadly the pig tribe, and many varieties of ruminants. These latter have their definite characteristics, and the former have their distinguishing peculiarities. But there is nothing that fills up the gap between the ruminants and the pig tribe. The two are distinct. So also is this the case between the groups of another class—reptiles. We have crocodiles, lizards, snakes, and tortoises, and yet there is nothing—no connecting link—between the crocodile and lizard, or between the lizard and snake, or between the snake and the crocodile, or between any two of these groups. They are separated by absolute breaks. If, then, it could be shown that this state of things was from the beginning—had always existed—it would be fatal to the doctrine of evolution. If the intermediate gradations which the doctrine of evolution postulates must have existed between these groups—if they are not to be found anywhere in the records of the past history of the globe—all that is so far a strong and weighty argument against evolution; while, on the other hand, if such intermediate forms are to be found, that is so much to the good of evolution, although, for the reason which I will put before you by-and-by, we must be cautious in assuming such facts as proofs of the theory.

It is a very remarkable fact that, from the commencement of the serious study of paleontology, from the time in fact when Cuvier made his brilliant researches upon the fossil remains of animals found in the quarries of Montmartre, Paleontology has shown what she was going to do in this matter, and what kind of evidence it lay in her power to produce.

I said just now that at the present day the group of pig-like animals and the group of ruminants are entirely distinct; but one of the first of Cuvier's discoveries was an animal which he called the *Anoplotherium*, and which he showed to be, in a great many important respects, intermediate in its character between the pigs on the one hand and the ruminants on the other; that, in fact, research into the history of the past did so far—and to the extent which Cuvier indicated—tend to fill up the breach between the group of ruminants and the group of pigs. All subsequent research has also tended in this direction; and at the present day the investigations of such men as Rütimeyer and Gaudry have tended to fill up and connect, more and more, the gaps in our existing series of mammals. But I think it may have an especial interest if—instead of dealing with these cases, which would require a great deal of tedious osteological detail—I take the case of birds and reptiles—which groups, at the present day, are so clearly distinguished from one another that there are perhaps no classes of animals which in popular apprehension are more completely separated. Birds, as you are aware, are covered with feathers; they are provided with wings; they are specially and peculiarly modified as to their anterior extremities; and they walk perpendicularly upon two legs; and those limbs, when they are considered anatomically, present a great number of exceedingly remarkable peculiarities, to which I may have occasion to advert incidentally as I go on, but which are not met with even approximately in any existing forms of reptiles. On the other hand, reptiles, if they have a covering at all, have a covering of scales or bony plates. They possess no wings; they are not volatile, and they have no such modification of the limbs as we find in birds. It is impossible to imagine any two groups apparently more definitely and distinctly separated. As we trace the history of birds back in time, we find their remains abundant in the tertiary rocks throughout their whole extent, but, so far as our present knowledge goes, the birds of the tertiary rocks retain the same essential character as the birds of the present day—that is to say, the tertiary bird comes within the definition of our existing birds, and are as much separated from reptiles as our existing birds are. A few years ago no remains of birds had been found below the tertiary rocks, and I am not sure but that some persons were prepared to demonstrate that they could not have existed at an earlier period. But in the last few years such remains have been discovered in England, though, unfortunately, in a very imperfect condition. In your

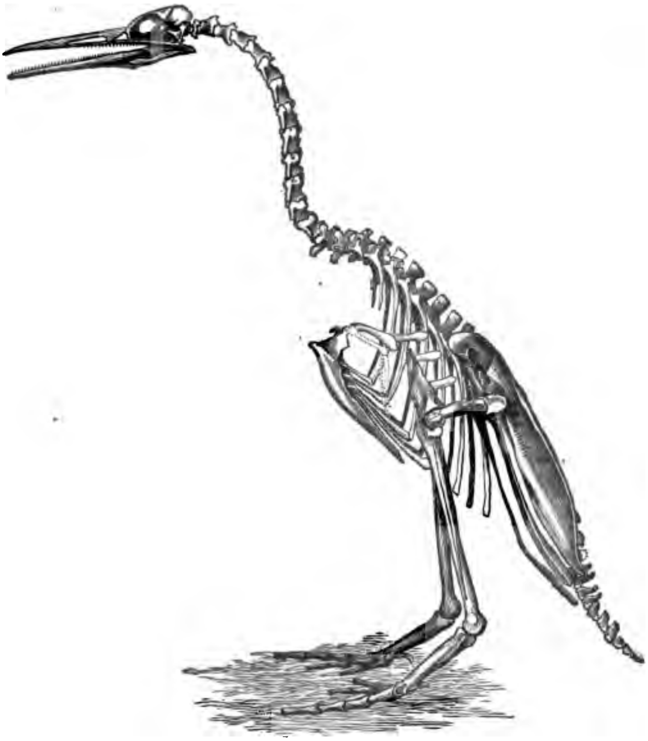

FIG. 2.—HESPERORNIS REGALIS. (Marsh.)

country the development of cretaceous rocks is enormous; the conditions under which the later cretaceous strata have been deposited are highly favorable to the preservation of organic remains, and the researches full of labor and toil, which have been carried on by Prof. Marsh in these Western cretaceous rocks, have rewarded him with the discovery of forms of birds of which we had hitherto no conception. By his kindness, I am enabled to place before you a restoration of one of these extraordinary birds, every part of which can be thoroughly justified. The remains exist in the greatest beauty in his collection. This *Hesperornis* stood about six feet high, and in a great many respects is astonishingly like an existing diver or grebe, so like

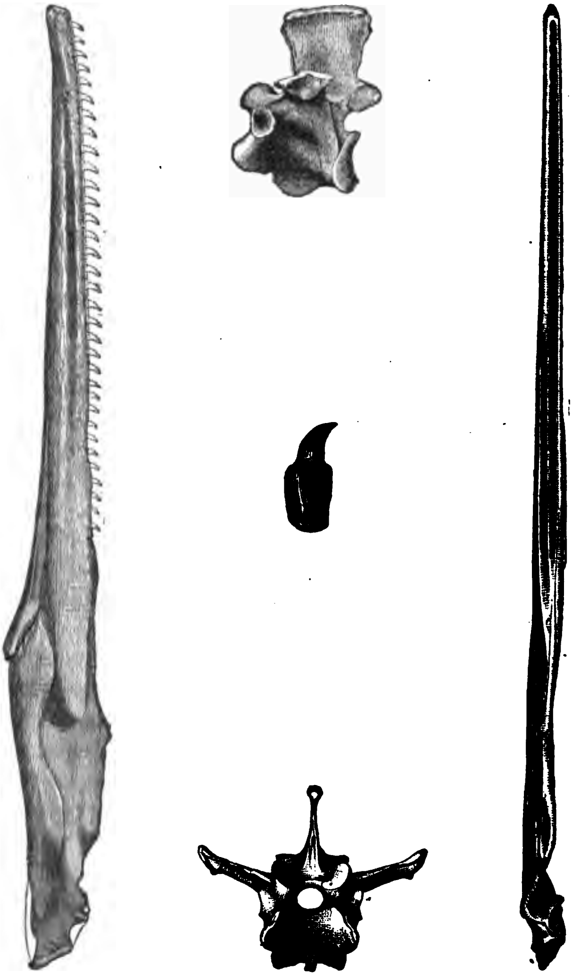

Fig. 3.—Hesperornis Regalis. (Marsh.)

it indeed that, had this skeleton been found in a museum, I suppose—if the head had not been known—it would have been placed in the same general group as the divers and grebes of the present day. But this bird differs from all existing birds, and so far resembles reptiles in one important particular that it is provided with teeth. These long jaws are beset by teeth, as in this diagram, in which one of the teeth is represented separately. In possessing true teeth, the *Hesperornis* differs entirely from any existing bird, and in view of the characteristics of this bird we are obliged to modify the definition of the class of birds and reptiles. Before the discovery of a creature such

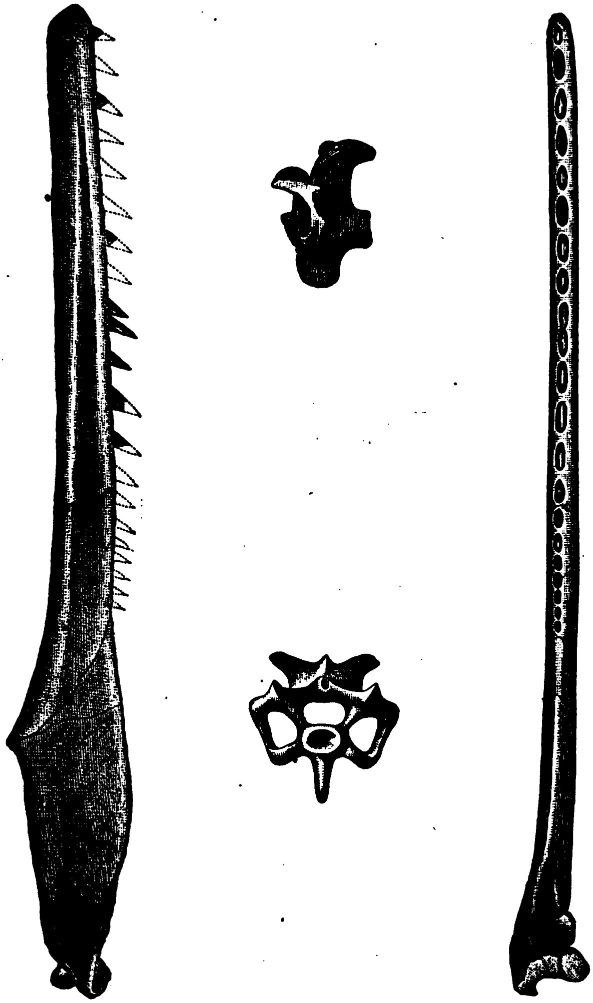

Fig. 4.—Ichthyornis Dispar. (Marsh.)

as this, it might have been said that birds were characterized by the absence of teeth; but the discovery of a bird that had teeth shows at once that there were ancient birds that, in that particular respect, approached reptiles more nearly than any existing bird does.

The same rocks have yielded another bird (*Ichthyornis*), which also has teeth in its jaws, the teeth in this case being situated in distinct sockets, while those of *Hesperornis* were not so lodged. The latter also had very small wings, while *Ichthyornis* has strong wings. *Ichthyornis* also differed in the fact that the joints of its backbone—its vertebræ—had not the peculiar character that the vertebræ of existing birds have, but were concave at each end. This discovery leads us to make another modification in the definition of the group of birds, and to part with another of the characters by which they are distinguished from reptiles. We know nothing whatever of birds older than these until we come down to the Jurassic period, and from rocks of that age we have a single bird which was first made known by the finding of a fossil feather. It was thought wonderful that such a perishable thing as a feather should be discovered and nothing more, and so it was; and for a long time nothing was known of this bird except its feather. But, by-and-by one solitary specimen was discovered, which is now in the British Museum. That solitary specimen is unfortunately devoid of its head; but there is this wonderful peculiarity about the creature that, so far as its feet are known, it has all the characters of a bird, all those peculiarities by which a bird is distinguished from a reptile. Nevertheless, in other respects, it is unlike a bird and like a reptile. There is a long series of caudal vertebræ. The wing differs in some very remarkable respects from the structure it presents in a true bird. In a true bird the wing answers to these three fingers—the thumb and two fingers of my hand—the metacarpal bones are fused together into one mass—and the whole apparatus except the thumb is bound up in a sheath of integument, and the edge of the hand carries the principal quill-feathers. It is in that way that the bird's wing becomes an instrument of flight. In the *Archæopteryx*, the upper-arm bone is like that of a bird; these two forearm bones are more or less like those of a bird, but the fingers are not bound together—they are free, and they are all terminated by strong claws, not like such as are sometimes found in birds, but by such as reptiles possess, so that in the *Archæopteryx* you have an animal which, to a certain extent, occupies a midway place between a bird and a reptile. It is a bird so far as its foot and sundry other parts of its skeleton are concerned; it is essentially and thoroughly a bird in the fact that it possesses feathers, but it is much more properly a reptile in the fact that what represents the hand has separate bones resembling those which terminate the fore-limb of a reptile. Moreover, it had a long tail with a fringe of feathers on each side. All these cases, so far as they go, you will observe are in favor of evolution to this extent, that they show that in former periods of the world's history creatures existed which overstepped the bounds of all existing classes and groups, and tended to fill up the intervals which at present exist between them. But we can go further than this. It is possible to fill up the interval between birds and reptiles in a much more striking manner. I do not think that this is to be done by looking upon what are called the *Pterodactyls* as the intermediate form between birds and reptiles. Throughout the whole series of the mesozoic rocks we meet with some exceedingly remarkable flying creatures, some of which attain a great size, their wings having a span of eighteen or twenty feet or more, and these are known as *Pterosauria*, or *Pterodactyls.* We find these with a bird-like head and neck, with a vertebral column sometimes terminated by a short and sometimes by a long tail, and in which the bones of the skeleton present one of the peculiarities which are often considered to be most characteristic of birds—that of having pneumatic cavities, which make

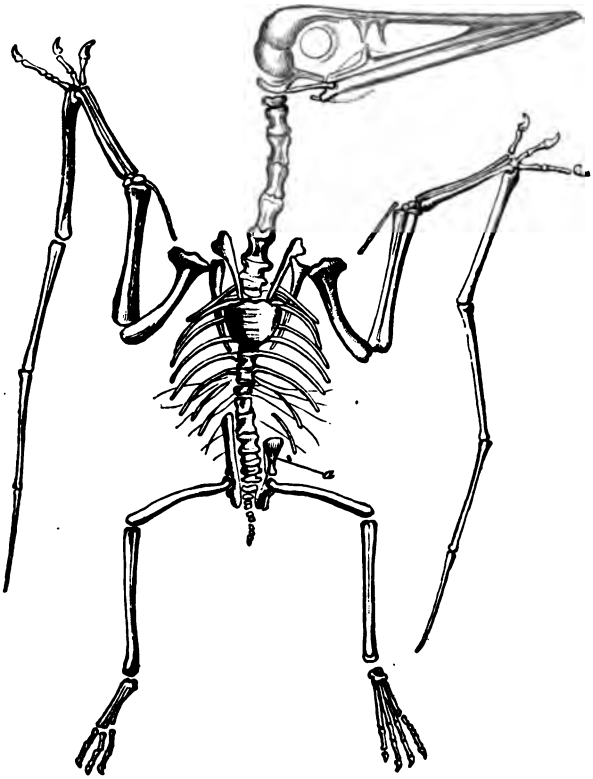

FIG. 5.—PTERODACTYLUS SPECTABILIS. (Von Meyer.)

the creature specifically light in its flight. Like a bird, this creature has a largish breastbone, but from that point onward, so far as I can see, special, particular resemblances end, and a careful examination of the fore-limbs shows you that they are not birds' wings; they are something totally different from a bird's wings. And then, again (pointing to a chart), those are not a bird's posterior extremities, but are rather a reptilian's hind-limbs. The vertebræ present nothing that I need dwell upon, but the bones of the hand are very wonderful.

There are four fingers represented. These four fingers are large, and three of them—these, which answer to these three in my hands—are terminated by claws, while the fourth is enormously prolonged into a great jointed style. You see at once from what I have stated about a bird's wing that there could be nothing more unlike a bird's wing than this is. It was concluded by general reasoning that this finger was made to support a great web like a bat's wing. Specimens now exist showing that this was really the case, that this creature was devoid of feathers, but the fingers supported a vast web like a bat's wing, and there can be no doubt that this ancient reptile flew after the fashion of a bat. Thus, though the pterodactyl is a flying reptile, although it presents some points of similarity to birds, yet is it so different from them that I do not think that we have any right to regard it as one of the forms intermediate between the reptile and the bird. Such intermediate forms are to be found, however, by looking in a different direction. Through the whole series of mesozoic rocks there occur reptiles, some of which are of gigantic dimensions; in fact, they are reckoned among the largest of terrestrial animals. Some of them are forty and fifty, possibly more, feet long. Such are the *Iguanodon*, the *Megalosaurus*, and a number of others, with the names of which I will not trouble you. There are great diversities of structure among these great reptiles. Some of them resemble lizards in the proportions of their limbs, and have evidently walked on all-fours, in that respect resembling the existing crocodile; but in others you can trace a series of modifications in virtue of which the hind-limbs at length completely assumed the character of a bird's hind-limbs. I here indicate (pointing to a diagram) the hind limb of a crocodile, showing the bones of the hind-limbs and of the pelvis. These are the haunch-bones; these are the two leg-bones. Then comes the division of the foot which we call the tarsus, in which the component bones are separate and distinct from one another, from the bones of the leg and from those of the metatarsus. Then come the four toes, which alone exist in the hind-feet of the crocodile, and which are separate and distinct. The foot is flat on the ground, so that the legs spread out and the weight of the body hangs clumsily between them. Contrast this with what we find in the bird—the haunch-bone here is immensely elongated, and the joints of the back-bone, between the two haunch-bones, are united so as to form a solid support upon which the weight of the body rests. Then the thigh-bone becomes very short, and has a back ridge upon its outer articular surface. At the lower end the ridge fits in between the upper extremity of the small bone of the leg, near to the great bone, and makes a kind of spring-joint. The small bone of the leg is quite large above, and becomes rudimentary below. It runs out into a style, instead of being long and large, as it is in the case of the crocodile. Then, when you come to the bones of the foot, you find there are no separate bones such as you have here, but the end of the tibia, or large bone of the leg, appears to end in a kind of pulley, a single bone follows the tibia and to the trifurcated extremity of this bone. Upon the extremity of that bone are attached three toes. It is obvious that the contrast between the crocodile's leg on the one hand, and the bird's leg on the other, is very striking. But this interval is completely filled up when you study the character of the hinder extremities in those ancient reptiles which are called the *Dinosauria*. In some of these the bones of the pelvis, and those of the hind-limb, become extraordinarily similar to those of birds, especially to those of young or fœtal birds. Furthermore, in some of these reptiles, the fore-limbs become smaller and smaller, and thus the suspicion naturally arises that they may have assumed the erect position. That view was entertained by Mantel, and was also demonstrated to be probable by your own distinguished anatomist, Leidy, but the discoveries of late years show that in some of these forms the

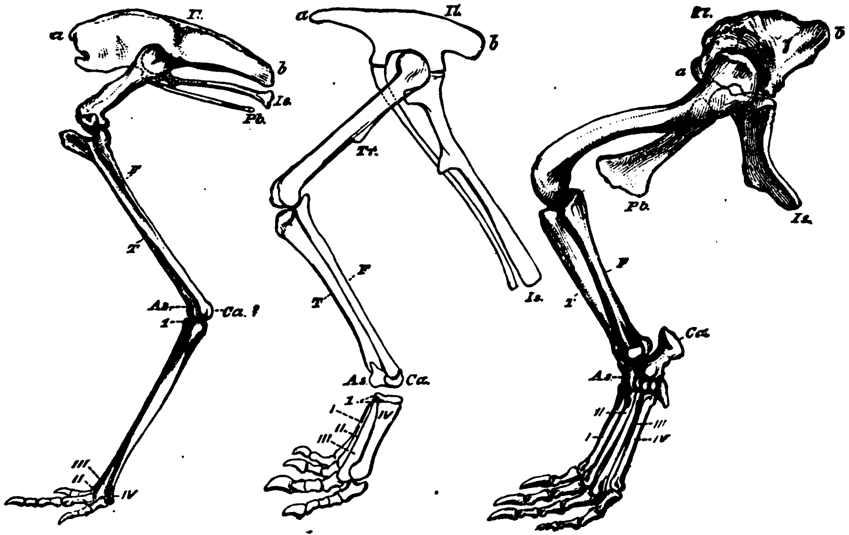

FIG. 6.—BIRD. DINOSAUR. CROCODILE.

fact was actually so; that reptiles once existed which walked upon their hind-legs as birds now do. The diagram is a faithful and accurate representation of an existing fossil except for this, that, whereas in the existing fossil the bones are twisted about and out of place, I have put them here in the position that they must have had in nature. You see a creature with a long neck and bird-like head, with very small anterior extremities, and that *compsognathous* creature must assuredly have walked about upon its hind-legs, bird-fashion. Add to this feathers, and the transition would be complete. Now to define it: The possession of teeth would, as we see, not separate this animal from the class of birds we have. We have had to stretch the class of birds so as to include birds possessed of teeth, and, so far as the character of the skeleton goes, we may fairly say that there needs here little more than the addition of feathers—and whether this creature had them or not we don't know—to convert it into a bird.

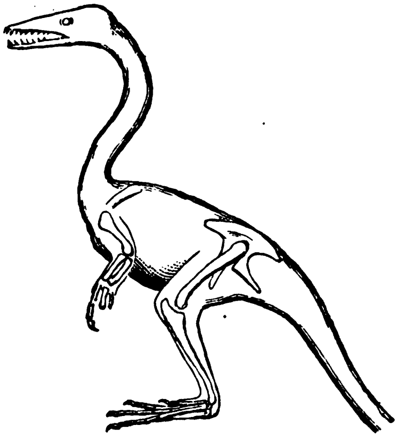

FIG. 7.—COMPSOGNATHUS LONGIPES. (Wagner.)

I have said that there can be no question, from their anatomical structure, that these animals walked upon their hind-legs, and, in fact, there are to be found in the Wealden strata of England gigantic footsteps arranged in order like these of the *Brontozoum*, and which there can be no reasonable doubt were made by *Dinosauria*, the remains of which were found in the same rock. And, knowing that reptiles that walked upon their legs and shared many of the anatomical characters of birds did once exist, it becomes a very important question whether those tracks in Massachusetts—to which I referred just now, and which formerly used to be unhesitatingly ascribed to birds—may not all have been made either by reptiles similar to the *Dinosauria*, or whether, if we could get hold of the skeleton which made these tracks, some of which are marvelously like bird's tracks, we should not come upon exactly that series of transitions by which in former days the reptile was connected with the bird.

I don't think, ladies and gentlemen, that I need insist upon the value of evidence of this kind. You will observe that, although it does not prove that birds have originated from reptiles by the gradual modification of the ordinary reptile into a dinosaurian form, and so into a bird, yet it does show that such a process may possibly have taken place, and it does show that, in former times, there existed creatures which filled up one of the largest gaps in existing animate nature, and that was exactly the kind of evidence which I stated to you in starting we are bound to meet with in rocks if the hypothesis of evolution be correct.

In my third and last lecture I will take up what I venture to call the demonstrative evidence of evolution.

ON VARIATION IN THE MOTHS.

By AUG. R. GROTE, A. M.

THERE are a large number of different kinds of moths, inhabiting North America and Europe, which entomologists have classified under the technical family term, *Noctuæ*. Of this family, 1,028 different species have been catalogued as European. There being very many students, and a sufficient time having elapsed to secure a thorough collecting throughout the territory, this number may be taken as sufficiently corresponding with the actual representation of the family in Europe. In North America nearly 1,200 species are now catalogued,[1] but, since much of our territory remains to be explored in this respect, we may expect considerable additions to the number of known *Noctuæ* inhabiting our continent. The greater number of the species may be easily distinguished on comparison, the American from the European. There are, however, certain American species which differ but very slightly from certain European, and hence are generally called "representative species," or "species of replacement." For instance, *Apatela occidentalis* (G. and R.) "represents" the European *Apatela psi* (Linn.); *Agrotis Normaniana* (Grote), the European *Agrotis triangulum; Calocampa nupera* (Lintner), the European *Calocampa vetusta; Catocala relicta* (Walk.), the European *Catocala fraxini*, etc.

Although the number of such species appears relatively small, it is probably in reality larger than as yet suspected. For even the species acknowledged to occupy this relationship to each other exhibit quite different degrees of resemblance. I say "relationship," for we must reasonably conclude that this resemblance is not accidental or meaningless. It must indicate that both the European and American species are derived from a common stock. More than two years ago, I suggested that the faunæ had become separated through the physical action of the glacial epoch, showing that from the present distribution of species, and their degree of resemblance, no other hypothesis would explain all the facts in the case so satisfactorily. For we have to account, first, for the occurrence of nearly-related forms in localities as widely separated, geographically, as Texas and Germany; and then, again, for the occurrence, within our territory, of nearly-related species on the Alpine summits of Mount Washington and the distant arctic regions. The method of probable distribution of these latter species, through the action of the retreating ice, I have explained in the *American Naturalist* for March of this year.

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[1] "List of the Noctuidæ of North America, 1875–'76." Buffalo, Reinecke & Zesch.

In studying specimens of these related American and European species of *Noctuæ*, some new light bearing upon the question of their differences is attempted to be thrown in the present paper. I have endeavored to localize these differences upon some portion of the insect. In all the cases I have been able to investigate, these differences are expressed on the upper surface of the body and wings, and principally on the upper surface of the front pair of wings. Here it is that the first variations, which now have grown into specific differences, were probably expressed. And the reason for this seems to be, that this portion of the body is that usually exposed to the light and the action of external influences. The moths, during the daytime, rest with the front-wings dependent over the hind-wings, and nearly covering the body. While in the American and European related species the differences which lead us to call them distinct "species" are located on the front-wings chiefly, the under surfaces of both wings remain exceedingly similar in the contrasted forms. This is the portion which in the day time (the period of inaction for moths) is applied to the surface against which the insect rests, and is entirely shielded from exposure. Take, for instance, the European *Catocala fraxini* and the American *Catocala relicta*. The ground-color of the American species above and below is a bright, clear white. Now, beneath, both species show this color, but the upper surface of the fore-wings, in the European species, is obscured by an evenly-distributed admixture of blackish scales, so that the wings appear of a uniform obscure gray. The hind-wings, in the European species, are crossed by a band of bluish scales; in the American, this band is white, while I have recently detected a slight powdered edging of blue scales, difficult to perceive, and apparently hitherto unnoticed. The principal difference in ornamentation is, again, to be found on the upper surface of the fore-wings. It lies in the course and shape of the transverse posterior line—a line which is a general feature of ornamentation throughout this group of insects.

This position might be sustained by parallel facts, but the limit of this article does not allow of their being presented. It remains to see what light these observations throw upon the origin of all these different kinds of moths. They seem to me to point to a method of variation in this group, and to a reason for its display. And, if we can apply these observations to particular instances, they may lead to a better understanding of the value of these specific forms, by allowing us to appreciate with more exactness the amount of differentiation they have undergone in the lapse of time. In a wider sense, we may attempt a classification by the ornamentation and coloration in the moths based on method, and such studies cannot fail to lend fresh interest to the barren but necessary work of describing the different species or forms. It seems to me, also, that these observations vindicate the importance of studying the characters of color and pattern in the group, and are, perhaps, a criticism on the remarks of those writers who purposely allow these no higher value than the subordinate one of dividing their material into "species" in their collections. In fact, these characters may give us a clew to the genealogy of the group, and seem to be of sufficient importance to be noted in descriptions of genera.

THE CONSTANCY OF MOTION.

By GEORGE ILES.

THE conservation of energy, as treated in the most recent work of authority on the subject, Prof. Balfour Stewart's, published in the "International Scientific Series," regards energy as divisible into two classes, actual and potential: actual energy, as in the case of a rushing stream of water, or a radiant and contracting mass of molten iron; and potential energy, where, for instance, a stone is at a height and may fall, or where a spring is tightly coiled and may unwind.

Prof. Stewart speaks the general opinion of modern physicists, Profs. Rankine, Tyndall, and others, when he states that, in cases of potential energy, the bodies endowed with it are absolutely at rest, and that the motion exhausted in storing up such energy is represented by a mere advantage of position, which, when utilized, yields in actual, palpable motion the energy which has lain completely quiescent, as when the stone falls to the earth, or the freed spring uncoils.

This division of energy into actual and potential seems to me to be defective. It prevents the direct comprehension in the mind of energy as being motion and nothing else; it leaves unexplained how a body perfectly at rest can come to move; and further implies the dissipation of energy (which I have treated in a previous number of this journal) in a new phase, for, if all the actual energy in the universe were to become potential, all the real and positive motions which constitute life might indefinitely cease.

Let us examine, then, some cases of "potential" energy, and see if they be not actual, although under a disguise; so that the present definition of the conservation of energy may be replaced by the more intelligible statement that motion is constant; that it is never abolished for a time, nor absolutely suspended, all appearances to the contrary notwithstanding; and that so, all cases of energy are dynamic, and no part of them static, as now currently held.

For matter seemingly at rest may contain within itself motions as real as those to which at another time it openly gives rise, when it radiates heat or attracts by magnetism.

First of all, then, let us consider the case of a stone at a height, say on the brow of a cliff, capable of falling at any time when slightly pushed.

Gravity is the one force, of all the forms of energy, whose relations with others it is most difficult to imagine.

Other forces affect each other most palpably: magnetism forsakes a magnet when it is made white hot; chemical affinity is most sensitive to variations of temperature, and even in some cases to mechanical tremor; the transmission of electricity is favored by the cooling of a conductor, and so on.

Otherwise is it with gravity: a given mass of matter, however mechanically moved, electrified, magnetized, heated, or subjected to chemical changes, at the same point on the earth's surface, always weighs the same.

The only force with which gravity has any analogy is magnetism; and were magnetism always attractive, instead of polar, with equal opposite manifestations of attraction and repulsion, the analogy would be a strong one.

Let us, however, work out what analogy there is, and we may find that as the subtile movements of light were made plain by the study of the grosser movements of sound in air, so may the long-hidden laws of gravity be revealed in part, by tracing the similitude existing between their effects and those of common magnetism.

Both forces obey the law of squares: according to that law, they diminish as we recede from their centres of attraction. And what is very suggestive is, that, as their appetites are satisfied, they decrease in exactly the same ratio.

Two small magnets at a great distance from each other (so as to be practically out of the range of each other's influence), having each a force equal to 1, when permitted to unite, have together a force less than 2; and this because work can be done by their attraction mechanically, or may appear as heat; and of course this must diminish their original stock of energy.

Precisely so with gravity. Suppose, for simplicity's sake, the radius of the earth to be 4,000 miles. Let us then imagine a stone of four tons lifted from the earth's surface to a distance of 4,001 miles; it would there weigh one ton—very nearly. Were such a mass to fall it would pass through 4,001 miles of space, and yield corresponding work.

Now let us further imagine a world, concentric with our present one, to be made up by the union of the earth with seven other such planets, and let us leave out of the question any possible condensation in the matter of this new world. Then supposing the stone to have resumed its former position in space, if gravity were allowed to act again, it could only do so through one mile, instead of 4,001 miles as before.

And mark how the geometrical necessities of enlargement lessen the working power of a mass attracting by gravity; for a stone weighing four tons on our present globe would only weigh twice as much on a sphere containing eight times the matter.

In the latter case, the surface would be twice as distant from the centre as in the former; for the attraction diminishes as the square of the distance of surface from the centre. Therefore the 8 times increased bulk has to be divided by 4, the square of the doubled radius.

Thus the weight of a definite mass on any celestial body varies as the density of the body and as the radius of it.

One of our pound-weights taken to the sun would there weigh 27 pounds, the sun's radius being about 110 times that of the earth, but its density only about one-fourth as great; while its bulk exceeds that of our planet by as much as 1,252,000 times.

If we now attentively observe the energy of a magnet in its usual genesis, we may learn somewhat, not only of gravity, but of attraction in general. The most convenient way to make magnets is by the use of an electric coil. A piece of properly-tempered steel is inserted in a helix of copper wire, through which a current circulates proceeding from the mechanical motion of a steam-engine, converted into electricity by suitable apparatus.

Other methods of magnetization there are, but none so directly instructive as this; here we have the visible, palpable motion of heavy wheels disappearing, and the chief result is the attractive force developed in the steel. The conviction dawns upon us that the motion of the wheels has been taken up by the molecules of the bar, that the steel has now internal movements which before it had not; and that these movements of its particles exist in full actuality, capable of doing tangible work when fitly permitted. Let us bring a piece of iron or steel near to the magnet, and instantly it leaps toward it, confirming our conviction.

That a medium exists for the conveyance of such molecular motion, we are obliged to think; but what it is, or how it is affected, we cannot yet imagine. Thus much, however, is plain, that, as a medium purely, it can be no source of motion, so that the mere fact of distance between bodies can be no satisfactory explanation of attraction.

Attraction, then, wherever it appears, I believe to be due to contained motion in the particles of the bodies presenting it; which molecular motion is the equivalent of, and convertible into, the movement of masses as wholes.

Gravity, I venture to hold, is a force due to a distinct motion of the ultimate parts of matter, which has not yet been formulated. And, as the energy expended in sundering two united magnets reappears in the increase of their attractive powers, or the acceleration of such motion of their particles as constitutes magnetism, so the lifting of a stone from the earth would imply that the force consumed in so doing must take the form of a quickening in that motion of its particles which constitutes gravity. And we have seen how every successive act of obedience to both these forces of aggregation makes them weaker and weaker, as it reasonably should.

Therefore, I conclude that the energy of a stone at a height is not potential, but actual; that its value as a source of work, at any time, is represented by the swifter motion of its molecules as compared with those of a stone on the earth's surface; and that, as a stone falls, its internal motion takes the phase of mass motion.

This theory would lead us to suppose that the onward momentum of the planets, as they turn before the sun, is the expression of an equal internal gravitive motion of their ultimate parts, which exactly balances these mighty celestial revolutions.

The next case of "potential" energy to be inquired into is that of a coiled spring, which, in unwinding, may yield the force it took to coil it.

This case may be intelligibly explained on the same principle of the constancy of motion. The particles of a spring may be assumed to have a definite plane of molecular motion, which motion we shall presume is that due to temperature. In coiling, these planes are changed, and energy is required to do it; just as when a gyroscope-top is rapidly revolving in a certain fixed plane, it may, by a measurable effort, be made to revolve in a conical curve, with one end of its axis stationary, and the other describing a circle in space. And, as the gyroscope strongly tends to move in a uniform plane, and can do work in resuming such a plane, so I assume that the particles in a coiled spring have two similar motions, one of which is at any time available for tangible work when the spring is freed.

Yet another example. Let us take the case of a cylinder of compressed air which for years, tightly sealed, may serve as a store of force.

Prof. Clerk Maxwell explains how an ounce of air, in a closed and fragile jar, sustains the outside pressure of the atmosphere amounting to several tons; this he does by the theory that the ounce of air is made up of molecules which have so rapid a motion among themselves that they collide on the inside of the jar with as great a force as that of the atmospheric pressure externally.

This theory, now widely accepted, rests on the solid grounds of the measured velocity of air rushing into a vacuum, which is the same as that assumed for its internal motion; and further, on some observations of the diffusion of various gases into each other, which it would be out of place to detail here.

On the basis, then, of Prof. Maxwell's theory, we can believe that, in a cylinder of compressed air, the energy stored up exists in no merely "potential" form, but in the full actuality of the rapid motion of gaseous particles, which may take the shape of mass-motion when the piston is allowed to move outward.

An extension of the hypothesis that motion is continuous would lead to the inference that the so-called latent heat of water at 32° Fahr., as compared with ice at the same temperature, is due to the swifter movement of the molecules in the former case; and no facts are better known than that mechanical motion can become heat, and that heat turns ice into water.

Another implication of this theory is that atoms, as free hydrogen, oxygen, or carbon, are in exceedingly greater commotion than molecules, such as those of water or carbonic-acid gas. For the decomposition of such molecules may be effected by the exhaustion of mechanical motion, and I take it that the dynamic state of the products must balance this expenditure. What else can become of it?

The measure of the contained motion in two different atoms can be noted on their combining chemically, by the increase of temperature, which has its well-known mechanical equivalent.

The analogy between chemical units and small magnets is very close: as a magnet decreases in size, so, relatively thereto, does its attractive power increase; and, were we able to go on dividing until we came to a single atom of iron, we should doubtless have the magnetism merge into the equivalent phase of intense chemical affinity.

Without further illustration, then, of the principle set forth, I will say that, as in recent years we have had to familiarize ourselves with the idea that many forms of actual energy are impalpable, as the rays of light and the waves of sound, so now I think there are good grounds for extending our ideas so as to believe that all phases of "potential" energy are really actual; that, as we cannot but think that only motion can breed motion, energy means motion; and that as such its amount is constant, and its presence, behind whatever veil, continuous; so that it is only properly divisible into two kinds, perceptible and imperceptible.

SKETCH OF PROFESSOR MAYER.

AMONG the younger physicists of the country who have done honor to American science by the interest and extent of their original researches, the subject of the present sketch, and of whom we give an excellent portrait this month, holds a distinguished place. Though now only in the prime of his manhood, he has already made many refined and elaborate experimental researches, by which he is widely and favorably known to men of science both in this country and in Europe.

Alfred Marshall Mayer was born in Baltimore, November 3, 1836. His grandfather, Christian Mayer, was descended from an ancient family in the city of Ulm, Würtemberg, and came to Baltimore when a young man. Here he made a large fortune in trade with India and Mexico. He was well known in his day for his liberal and elegant hospitality, his extensive reading, profound knowledge of mercantile law, and those marked social and gentlemanly traits that made him a delightful companion. His father was Charles F. Mayer, who was distinguished for his learning, eloquence, and extensive literary culture. He is the nephew of Brantz Mayer, a prominent writer, who is especially known by his various valuable works on Mexico, where he resided for a time as secretary of legation.

Prof. Mayer was partly educated at St. Mary's College, in Baltimore, which he left at the age of sixteen for a more practical sphere of study. He entered the workshop and draughting-room of a mechanical engineer, where he remained two years, acquiring a knowledge of the use of tools, mechanical drawing, the method of constructing machines, and careful mechanical manipulation. Subsequently, during two years, he cultivated analytical chemistry by thorough laboratory practice.

Prof. Mayer has occupied the chair of Physics, with Chemistry and Astronomy, in several colleges, as follows: University of Maryland, 1856–'58; Westminster College, Missouri, 1859–'61; Pennsylvania College, Gettysburg, 1865–'67; Lehigh University, Bethlehem, Pennsylvania, 1867–'70; and the Stevens Institute of Technology since 1871. In 1863–'64 he studied physics, mathematics, and physiology, in the University of Paris.

Prof. Mayer's first contribution to science was made in 1855, and described in a paper in the *American Journal of Science and Arts*, entitled "A New Apparatus for the Determination of Carbonic Acid," which was republished in Germany. His second paper was on the estimation of weights of very small portions of matter, in which he showed that, by the deflections of fine glass fibres, we can weigh a particle of matter as small as the $\frac{1}{1000}$ of a milligramme. While at the Lehigh University, he designed and superintended the erection of an astronomical observatory, put together and adjusted the instruments, and made a series of observations on the planet Jupiter, which were republished in England. He was in charge of the party sent by the United States Government to observe the eclipse of the sun at Burlington, Iowa, August 7, 1869, and took forty-one perfect photographs of the eclipse with exposures lasting only the $\frac{1}{500}$ of a second.

While at the Lehigh University, Prof. Mayer contributed to the *American Journal of Science and Arts* and the *Journal of the Franklin Institute* various original contributions on the "Solar Protuberances," "Spectral Analysis of the Stars," "Physical Constitution of the Sun," "Electro-Magnetism," "Electric Conductivities," "On the Alleged Electro-Tonic State," "Magnetic Declination in Connection with the Aurora," "Photographing the Magnetic Spectra;" and at the Salem meeting of the American Association he read an instructive paper "On the Thermo-Dynamics of Waterfalls." He had taken the temperatures of the water at Trenton and Niagara before it leaps the cataract and after it strikes below. According to theory, when the falling motion is arrested, it is converted into heat, and should be shown in a rising temperature below. The observations indicated that the effects of evaporation and contact of the divided water with the air were greater than the impact in changing the temperature of the fallen water, so that it may be actually colder below than above. But on days when the air is saturated with moisture, and the temperatures of the water and air are about the same, results were obtained which show that the warming of the falling water conforms to Joule's law of the conversion of motion into heat.

Since entering upon his duties at the Stevens Institute of Technology, notwithstanding the labor of lecturing and teaching which the position involves, Prof. Mayer has conducted elaborate investigations in various branches of physics, which have given to science many new and important results. Among these may be mentioned researches in magnetism, heat, and especially "On the Effects of Magnetization in changing the Dimensions of Iron and Steel Bars," and "On the Isothermals of the Solar Disk." We cannot here give the particulars of these interesting inquiries, but must refer the reader to the memoirs in the scientific journals.

The line of investigation, however, to which Prof. Mayer has mainly devoted himself within the last few years is that of acoustics in its various physical connections, and especially in relation to the theory of music. These researches are described in papers contained in the *American Journal of Science and Arts*, and several of his important conclusions have been incorporated in the English edition of Helmholtz's "Sensations of Tone as a Physiological Basis for a Theory of Music." Mr. Alexander J. Ellis, F. R. S. (the translator of the above work), has also recently published a lecture which he delivered before the London Musical Association, on the application of Prof. Mayer's discoveries to the elucidation of the fundamental principles of musical harmony.

The chief claims of Prof. Mayer in regard to his recent acoustical results may be concisely summed up as follows:

1. He discovered that, by using the phenomena of sympathetic vibration, one can show that the translation of a vibrating body causes it to give sonorous waves, differing in length from those produced by the same vibrating body when stationary.

2. He first succeeded in actually detecting the different phases of vibration *in the air surrounding a sounding body*, and thereby measured the lengths of its waves; and first experimentally explored in the free air the exact form of any wave-surface; and he has determined the forms of these envelopes around a sounding body with as much facility as one can obtain the form of the surface of a palpable body *in the dark.*

3. He devised a simple and accurate method of measuring the wave-lengths of sound in air and in gases, and was the first to measure with precision the relative intensities of sounds by means of manometric flames.

4. He first approximately determined the mechanical equivalent of an aërial sonorous vibration.

5. He obtained in an experiment all the conditions required in "Fourier's theorem," and thus first gave an exact experimental confirmation of it.

6. He has devised and used *five* new methods of sonorous analysis for the decomposition of a compound sound into its elementary simple tones. He also first, by means of a rotating disk, reproduced the vibratory motions of a molecule of air, when it is animated with the resultant action of the six elementary vibrations forming a musical note.

7. He first discovered, by delicate experiment, that the fibrils of the antennæ of the male mosquito vibrate sympathetically to notes which have the range of pitch of the sounds given out by the female mosquito. He also showed first how an insect may determine the direction of sounds by means of his antennæ.

8. He discovered that the terminal auditory nerve-fibrils vibrate half as often in a given time as the membrane of the tympanum and

the ossicles of the ear, and proposed on these facts a new hypothesis of the mode of audition.

9. He first discovered the law connecting the pitch of a sound with the time that the sensation of the sound endures after the air has ceased to vibrate the tympanic membrane. This law rendered the qualitative results of Helmholtz quantitative; and in the third edition of Helmholtz's "Tonempfindungen" Mr. Alexander J. Ellis, as noted above, has extensively used this law as the only basis for reaching exact quantitative results in the fundamental phenomena of musical harmony. This law Prof. Mayer has applied extensively to the elucidation of the fundamental facts of harmony, and to the explanation of many obscure phenomena in the physiology of hearing.

10. He discovered that sonorous sensations interfere with one another, and that, although a low sound may entirely obliterate the sensation of a sound *higher* in pitch, yet a sound cannot in the slightest obliterate the sensation of another sound *lower* than it in pitch. He has made applications of these discoveries in showing that a radical change is required in the usual method of conducting orchestral music, and in a new method of determining the relative intensities of sounds.

11. He has determined with great precision the laws of the vibrations of tuning-forks, especially in the direction of the bearing of these laws on the action of chronoscopes used in determining the velocities of projectiles. He first accurately gave the correction to be applied in all such determination on account of the different temperatures of the forks.

Besides these difficult and delicate original investigations, Prof. Mayer has contributed numerous articles to Appletons' and Johnson's "Cyclopædias" in his more especial lines of inquiry, and has written much for various popular publications. He was one of the editors of the *American Journal of Science and Arts*, but reluctantly gave up its duties in 1873 on account of weakness of sight. He then suspended work, and went to England for a vacation, where he was cordially received and kindly entertained by his brethren of the various scientific societies.

CORRESPONDENCE.

FIGHT BETWEEN A TROUT AND A WATER-SNAKE.

To the Editor of the Popular Science Monthly.

HAVING read in your July number Mr. Buckland's account of a fight between a scorpion and a mouse, I am induced to give you an account of a remarkable conflict between a large water-snake and a trout, witnessed by myself and one of my brother officers in the survey in 1867, on the Purissima, a small trout-stream which empties into the ocean about twenty-four miles south of San Francisco. We had been fishing on the stream, and came to a high bank which overlooked a transparent pool of water about ten feet in diameter and four feet in depth. This pool was fringed with willows, and had on one side a small gravel-bank. The trout at first sight was lying in mid-water, heading up-stream. It was, as afterward ascertained, fully nine inches in length, a very desirable prize for an angler. While studying how to cast our flies to secure him, a novel fisherman appeared, and so quick were his actions that we suspended our own to witness them. This new enemy of the trout was a large water-snake of the common variety, striped black and yellow. He swam up the pool on the surface until over the trout, when he made a dive, and by a dexterous movement seized the trout in such a fashion that the jaws of the snake closed its mouth. The fight then commenced. The trout had the use of its tail and fins, and could drag the snake from the surface; when near the bottom, however, the snake made use of its tail by winding it around every stone or root that it could reach. After securing this tail-hold it could drag the trout toward the bank, but, on letting go, the trout would have a new advantage. This battle was continued for full twenty minutes, when the snake managed to get its tail out of the water and clasped around the root of one of the willows mentioned as overhanging the pool. The battle was then up, for the snake gradually put coil after coil around the root, with each one dragging the fish toward the land. When half its body was coiled it unloosed the first hold and stretched the end of its tail out in every direction, and, finding another root, made fast, and now using both dragged the trout out on the gravel-bank. It now had it under control, and, uncoiling, the snake dragged the fish fully ten feet up on the bank, and I suppose would have gorged him. We killed the snake, and replaced the trout in the water, as we thought that he deserved liberty. He was apparently unhurt, and in a few moments darted off. That the water-snake of our California brooks will prey upon the young of trout and also smaller and less active fishes, I have noticed, but never have seen an attack on a fish so large or one more hotly contested. Yours respectfully,

A. W. CHASE,
Assistant U. S. Coast Survey.

EDITOR'S TABLE.

THE NEW YORK AQUARIUM.

THE devotees of rational amusement, the lovers of natural history, and the friends of scientific education, in this city, are to be congratulated on the establishment of the aquarium which was recently completed and opened to visitors. Undoubtedly the devotees of rational amusement are not so numerous as they might be, but they will increase in numbers as increasing facilities are afforded for combining agreeable recreation with instructive observation in the acquisition of pleasant knowledge without much trouble. As a means of increasing the general taste in natural history, and affording students the opportunity of familiarizing themselves with forms of life hitherto inaccessible and known chiefly in books, the aquarium is invaluable, and will be a great help in promoting the work of science. The museum shows us dead specimens, stuffed, dried, and variously preserved, and is of course not without interest. But the aquarium opens to us the living, moving curiosities and wonders that are nowhere else to be seen. What the menagerie is to the creatures of the forest, the desert, and the prairie, the aquarium is to the tenants of the lake, the river, and the ocean. But, while land-animals have long been captured and collected for inspection, the aquarium is a new and recent affair, involving great difficulties in its successful management. These difficulties can only be overcome at large expense, by persevering experience, and through special and thorough knowledge of the conditions of life of an immense variety of aquatic creatures. The opportunity such an establishment opens to the scientific observer, investigator, and experimenter, should be highly prized, and we have no doubt it will be well appreciated by this class of students.

In an educational point of view, or as a means of popular instruction, a well-stocked aquarium cannot fail to be of the highest value. Natural history is a growing subject in our schools, but is so generally pursued merely from text-books which give no real knowledge, that a great available museum of living objects is precisely what is wanted to give reality and efficiency to this branch of study. The New York Aquarium should be brought into very close relations with the common-school system of the city. We are glad to observe that this element of its usefulness has not been overlooked in the plan and management of the enterprise. Provisions for study, instruction, and systematic observation have been incorporated with it, and this feature has been held so important as to be placed in special charge of a cultivated naturalist. Mr. W. S. Ward, who has been abroad this season and visited the chief aquariums of Europe, with a view of acquiring information that will be valuable to the scientific management, will devote himself to the educational service of the institution.

It is a noteworthy fact that we are indebted for the New York Aquarium entirely to private enterprise. There was talk that the city would establish something of the kind in the Central Park; but it came to nothing, and, after the municipal fizzle over the fossil restorations undertaken by Mr. Waterhouse Hawkins, we may conclude that it was perhaps best that the city did not undertake this work. But what it was unable or disinclined to do has been projected and carried out by the persevering enterprise of Mr. W. C. Coup, who has devoted his energy to its organization, and risked his money upon his chance of success. The aquarium is an honor to this metropolis and promises a large benefit to the public, and it should be liberally patronized and well sustained. We have no doubt it will meet from all classes with the encouragement it certainly deserves.

A CASE IN MENTAL PHYSIOLOGY.

An account comes to us of an enterprising Englishwoman who was equal to the following exploits in sharp practice: "By a series of the most extraordinary misrepresentations and cleverly carried out impostures, she raised large sums of money on no security whatever, and spent them as recklessly; imposed on jewelers so that they trusted her with goods worth many hundreds of pounds; furnished grand houses entirely at the expense of trusting upholsterers; introduced herself by sheer impudence to one great nobleman after another, and then introduced her dupes, who, on the faith of those distinguished social connections, at once disgorged more money. To one person she was a great literary character; to another, of royal descent; to another she had immense expectations; to another, she was a stern religionist."

This woman must have been as smart as she was unscrupulous. Her capacity of imposture was as marked as the deficiency of moral sense; she was as shrewd and long-headed as she was knavish. The art of her conduct, the consummate calculation, and the skillful adaptation of means to ends in dealing with others, implicate the whole intellectual sphere of action which was at the same time exempt from the control of conscience. Yet the force of moral considerations was implied throughout as she had to deal with people who were influenced by them, and to give good reasons for her various claims and representations. It was a sufficiently obvious case of cool criminal depravity, and most people would have little difficulty in deciding what was to be done about it. But current theories of conduct stop with mental *effects*. Mind being regarded as having a sphere of its own, and the mental world being held as an independent world, where all that goes on is purely psychical, there is no interest or requirement to look beyond the open manifestations of mind to their causes in another sphere. If we should say that this woman had something more than a mind, something more than an immaterial responsible soul, that we must look deeper than the mental manifestations displayed in conduct, that she had a brain made up of cells, fibres, tissues, and circulating blood, subject to the laws of nutrition, waste, and repair, debility, degeneration, and disease, and that all these things must be taken into account as controlling conditions of mental effects, we should be met immediately by the cry of *materialism!* And if we should furthermore say that these three or four pounds of nervous matter must come into consideration before society can proceed to decide upon such a case, a cry of denunciation would be raised against a destructive materialism that threatens to subvert the order of society.

Nevertheless, the question of mind in this case was an organic problem of the brain, as the further facts will show. This woman had lived a quiet but honest and uneventful life up to the time that she suddenly struck out into her sensational career. A year of lying, cheating, and scheming practices ended in the development of marked insanity and brain-disease, when she was taken to the Royal Edinburgh Asylum for the Insane, where she soon died. The victims of her cunning and mendacity were simply the dupes of a lunatic, and the question of her character and accountability resolves itself into a problem of brain-derangement, of morbid material conditions, and is therefore a question of practical materialism which the physician cannot escape.

EVOLUTION AND THE COPERNICAN THEORY.

It is significant that nearly all the divines who have spoken, in reply to Prof. Huxley, commit themselves to some form of the doctrine of Evolution. While, however, they admit that there is *some* truth in it, there is a common protest against the idea that it contains *much* truth—not by any means so much as is claimed by Prof. Huxley. He said that the evidence for it is demonstrative, and that it is as well based in its proofs as the Copernican theory of astronomy. This is thought to be quite absurd. It is said that Huxley may know a great deal about animals and fossils, but that obviously he knows very little about logic. His facts being admitted, a great deal of effort has been expended to show that he does not understand how to reason from them.

The Rev. Dr. William M. Taylor, in a letter to the *Tribune*, takes up Prof. Huxley on this ground, and is quite shocked at his logical incapacity. The following is a sample passage from his communication, and a very fair example, besides, of the sort of comment which his lectures have elicited:

> "Indeed, to affirm, as he did, that evolution stands exactly on the same basis as the Copernican theory of the motions of the heavenly bodies, is an assertion so astounding that we can only 'stand by and admire' the marvelous effrontery with which it was made. That theory rests on facts, presently occurring before our eyes, and treated in the manner of mathematical precision. It is not an inference made by somebody from a record of facts, existing in far-off and prehistoric, possibly also prehuman ages. It is verified every day by occurrences which happen according to its laws. But where do we see evolution going on to-day? If evolution rests upon a basis as sure as astronomy, why do we not see one species passing into another now, even as we see the motions of the planets through the heavens? . . . We know that astronomy is true, because we are verifying its conclusions every day of our lives on land and on sea. We set our clocks according to its conclusions, and navigate our ships in accordance with its predictions, but where have we anything approaching even infinitesimally to this, with evolution?"

The author of this passage is said to be a man of eminence and ability. That may be, but he certainly has not won his distinction either in the fields of logic, astronomy, or biology. When a man undertakes to state the evidence of a theory, and gives us proofs that equally sustain an opposite theory, we naturally conclude that he does not know what he is talking about. This is very much Dr. Taylor's predicament. In trying to contrast the evidence for evolution with the demonstrative proofs of the Copernican theory, he cites facts that are not only as good, but far better, to prove the truth of its antagonist, the Ptolemaic theory.

Dr. Taylor talks as if the Copernican theory is something that anybody can see by looking up into the sky, but the case is far from being so simple. The Copernican theory of the planetary motions assumes that they take place around the sun as their centre; the Ptolemaic theory taught that the earth is the stationary centre of the system, and that the sun, moon, and planets, revolve around it. We must not forget that the Ptolemaic theory was the fundamental conception of astronomy, and guided its scientific development for two thousand years. It was based on extensive, prolonged, and accurate observations; was elucidated and confirmed by mathematics—geometry, and trigonometry; and was verified by confirming the power of astronomic prevision. The planetary motions were traced and resolved on this theory with great skill and correctness, elaborate tables being constructed which represented their irregularities and inequalities, so that their future positions could be foretold, and conjunctions, oppositions, and eclipses, predicted. It embodied a great amount of exact knowledge, and was capable of taking in and preserving all the new results of the labors of a long series of Greek, Latin, Arabian, and modern European astronomers. Dr. Whewell says of it: "In this sense, therefore, the Hipparchian theory was a real and indestructible truth, which was not rejected, and replaced by different truths, but was adopted and incorporated into every succeeding astronomical theory, and which can never cease to be one of the most important and fundamental parts of our astronomical knowledge."

Copernicus, then, did not abolish but rather revised the old astronomy. He accepted the whole system of eccentrics and epicycles, and, so far as planetary motions are concerned, he simply recentred the solar system. He showed that the evidence in favor of that view preponderated, and his theory was a victory of refined, remote, and indirect investigation.

Dr. Taylor tells us that the Copernican theory "rests on facts presently occurring before our eyes." So does the Ptolemaic theory; and not only that, but, if the test is what occurs before our eyes, then the Ptolemaic theory is a thousand times stronger than the Copernican. If the Copernican theory is so obvious, if it "rests on facts presently occurring before our eyes," why did the astronomers of twenty centuries fail to discern it? Why could not the divines of Copernicus's time see it when it was pointed out to them? And why could not Lord Bacon admit it a hundred years after Copernicus? Dr. Taylor says, "It is verified every day by occurrences that happen according to its laws." So was its opposite, the Ptolemaic theory. Our reverend logician says, furthermore: "We know that astronomy is true, because we are verifying its conclusions every day of our lives, on land and on sea. We set our clocks according to its conclusions, and navigate our ships in accordance with its predictions." And all this they did with the astronomy that preceded Copernicus. Yet the author of this rubbish airs his logical pretensions, and talks about the "effrontery" of Prof. Huxley. Where is his shame?

The Copernican theory is held as demonstrably true, but it is not because everybody can see the demonstration. There was demonstrated truth in the opposite theory, though the proof was not so complete. And in regard to this matter of demonstration, of which so much is said, we have to remember that evidence is a thing of degrees. There may be evidence for a proposition which is so small that we hardly regard its truth as possible—we do not believe it. There is a grade of proof that amounts to probability, but leaves us in uncertainty. There are higher degrees of proof that confer assured belief, and leave little room for doubt. There is, again, evidence so perfect and decisive as to give certainty of conviction, and this we call demonstration. And evidence may have a yet higher shade of intensity, as where we cannot even conceive the opposite of a proposition to be true, and this may be characterized by the frequent expression, "absolute demonstration." The best examples of demonstration are furnished by mathematics in consequence of the fewness and simplicity of mathematical ideas, but demonstration by no means necessarily involves mathematics. There is plenty of demonstrated truth that is not mathematical. The anatomist demonstrates his science by observation, and the chemist by experiment. Fossils found in the rocks demonstrate that life existed upon the globe before the rocks were formed; and the vestiges of art found in Western mounds demonstrate that a race of men superior to the savages formerly lived upon this continent. A theory is said to be demonstrated when it brings all the known facts into agreement, explains them, excludes all other interpretations, and is consistent with itself and all that is understood of the ways of Nature. Most theories of the operations of Nature have about them traces of the imperfection that belongs to all things human, difficulties that are still unresolved, while yet the evidence for them may be so overwhelming as to be held demonstrative.

How is it, now, with the proof of the theory of Evolution, which assumes that the immense diversity of living forms now scattered over the earth has arisen through a long process of gradual unfolding and derivation, within the order of Nature, and by the operation of natural laws? It involves and is built upon a series of demonstrated truths. It is a fact accordant with all observation, and to which there never has been known a solitary exception, that the succession of generations of living things upon earth is by reproduction and genetic connection in the regular order of Nature. The stream of generations flows on by this process, which is as much a part of the settled, continuous economy of the world as the steady action of gravity or heat. It is demonstrated that living forms are liable to variations which accumulate through inheritance; that the ratio of multiplication in the living world is out of all proportion to the means of subsistence, so that only comparatively few germs mature, while myriads are destroyed; that, in the struggles of life, the fittest to the conditions survive, and those least adapted perish. It is a demonstrated fact that life has existed on the globe during periods of time so vast as to be incalculable; that there has been an order in its succession by which the lowest appeared first, and the highest have come last, while the intermediate forms disclose a rising gradation. It is a demonstrated truth of Nature that matter is indestructible, and that therefore all the material changes and transformations of the world consist in using over and over the same stock of materials, new forms being perpetually derived from old ones; and it is a fact now also held to be established, that force obeys the same laws. All these great truths harmonize with each other; they agree with all we know of the constitution of Nature; and they demonstrate evolution as a fact, and go far toward opening to us the secondary question of its method.

The reverend writer, whom we have quoted, asks, "If evolution rests on a basis as sure as astronomy, why do we not see one species passing into another now, even as we see the motions of the planets through the heavens?" To this foolish question, which has nevertheless been asked a dozen times by clerical critics of Huxley, the obvious answer is, that what requires a very long time to produce cannot be seen in a very short time. Has the writer ever seen the production of a geological formation? That he has not seen the evidences that would have prevented him from asking such a question is probably because he is not a student of Nature, and has not looked for them.

There has been much complaint that Prof. Huxley undertook to put the demonstrative evidence of evolution on so narrow a basis as the establishment of the genealogy of the horse, but this rather enhances than detracts from his merit as a scientific thinker. It has been well remarked that "the genius of the discoverer appears in his perceiving how small a number of facts, rightly considered, are sufficient to form a foundation for a theory." Kepler had to fix but a few points in the path of Mars, to demonstrate the ellipticity of his orbit, and to subvert the theory of circular planetary motions, by which the way was paved to the Newtonian astronomy. Prof. Huxley could have accumulated a far more striking display of the proofs of evolution for a popular audience, but he preferred to rest the question on evidence that was none the less decisive because it was restricted. If the horse has been derived from preceding forms in the way he pointed out, then that is the method of Nature—unless we deny the unity of its order.

And here is the vital point between Prof. Huxley and his antagonists. It is a question of the validity of the conception of the order and uniformity of Nature. Prof. Huxley holds to it as a first principle, a truth demonstrated by all science, and just as fixed in biology as in astronomy. His antagonists hold that the inflexible order of Nature may be asserted perhaps in astronomy, but they deny it in biology. They here invoke supernatural intervention. Obviously there are but two hypotheses upon the subject, that of the genetic derivation of existing species, through the operation of natural law, and that of creation by miraculous interference with the course of Nature. If we assume the orderly course of Nature, development is inevitable; it is evolution or nothing. If the order of Nature is put aside and special creation appealed to, we have a right to ask on what evidence? It was long maintained that the universe was made in a week, by a quick succession of divine fiats. This view is now abandoned, and it is maintained, *as a new theory*, that the millions of species which science has proved to have appeared all along the course of geological time were also the products of miraculous agency. But, as logic has been appealed to, we again press the question, on what evidence? There is no evidence. There is not a scintilla of proof that can have a feather's weight with any scientific mind. We are told that each link in the chain of ancestry of Prof. Huxley's horse was a special creation. But who tells us this, and what do they know about it? Genetic derivation is in the field as a real and undeniable cause; but what possible ground is offered for the alternative supposition? Has anybody ever seen a special creation? Do those who believe in it represent to themselves any possibility of how it could have occurred? Milton attempted to form an image of the way the thing was done, and says that the animals burst up full-formed and perfect like plants out of the ground—"the grassy clods now calved." But clods can only calve miraculously. Nature does not bring them into the world now by this method, and science certainly can know nothing of it. So far from being possible, so far from being probable, so far from being proved, this hypothesis of the origin of animal forms is simply unthinkable; it is a violation not only of the order of Nature, but of the very conditions of thought. From this point of view, therefore, the theory of evolution differs from the Copernican theory by having no alternative possibility. The Copernican theory was but the revision and modification of a preceding theory which had evidence in its favor, and could be rationally held by scientific minds; the evolution theory has a force of demonstration derived from the fact that the only alternative view cannot for a moment be entertained by any mind that recognizes the logical force of scientific evidence; in this respect, therefore, the evidence for evolution is even stronger than that for the Copernican theory.

LITERARY NOTICES.

The Theory of Sound in its Relation to Music. By Pietro Blaserna, of the Royal University of Rome. With numerous Illustrations. Pp. 187. Price, $1.50. International Scientific Series, No. XXII.

Nothing could be more appropriate than that the first Italian contribution to the "International Scientific Series" should take up one of the most interesting relations of science to art. Italy has been long preeminent as the land of artistic genius, although her distinction has been chiefly won by cultivating the arts that appeal to the eye—painting, sculpture, and architecture. Germany leads in the modern development of musical art, and her great physicist, Helmholtz, stands first as the elucidator of the laws of sound applied to musical science. But the great work of Helmholtz is a sealed book to the people. Prof. Blaserna has been first to take the brilliant results of recent acoustical progress and apply them to musical art and theory in so clear and familiar a manner that common readers will follow him with ease and pleasure.

The work is addressed both to scientific students and to musicians, but it is properly a contribution to the science of music. It does not at all cover the ground of Prof. Tyndall's volume on "Sound," which is strictly a text-book of acoustics, but, starting with so much of acoustical principles as is necessary for his purpose, Prof. Blaserna devotes the work to those scientific elucidations of musical art and practice which will have the greatest interest to those concerned in musical study. We cannot better give account of the volume than by quoting freely from the admirable review of it that has just appeared in the London *Lancet*. The writer says: "This work is an attempt to popularize the theory of music, and so to combine the theoretical with the practical study of this art that instrumentalists may obtain some knowledge of those fundamental laws of sound on which music is based. With this object in view Prof. Blaserna commences his treatise by explaining the laws of vibrations of strings and pipes, and shows how such vibrations may be measured; he then explains the theory of music in reference to the consonant and dissonant intervals, pointing out how the various ratios in the octave have been introduced, together with the nature of the perfect major and minor chords, the inversion of which, he observes, constituted the principal resource of Palestrina and of the composers of his school. This leads him to speak of dissonances, and of the nature of the musical scales. An exceedingly interesting *résumé* is then given of the history of music from the earliest period to the present day. In the music of all nations, Prof. Blaserna remarks, two unfailing characters are found —rhythmic movement and procedure by determinate intervals. The former appertains to many of the actions of man, but the second belongs exclusively to music. The instrument of Orpheus, however powerful its effects may have been in rendering inanimate objects 'sequacious of the lyre,' was but a poor instrument, consisting only of the following four notes: C, F, G, and the octave C. It is remarkable that this scale contains the most important musical intervals of declamation, the voice rising a fourth in making an interrogation, another a fifth higher in emphasizing a word, while in ending a story it falls a fifth. In speaking of Greek music he explains the difference between the Pythagorean and the modern scale. The ancient Scotch and Chinese scale, in which an enormous number of popular songs are written, consists of a succession of fifths, B*f*, F, C, G, D.

"The inventor of the modern system of musical notation was Guido d'Arezzo, and by him and Josquino and Orlando Tasso polyphonic music underwent great development. Then came the Reformation, and church music was greatly simplified to enable the whole congregation to join in it. An elaborate discussion of the characters of the major and minor scales succeeds, with an account of the effects of transposition. The temperate scale in common use is then explained, and its imperfections are declared to be so manifest that the author expresses a hope it will eventually be abolished. It is, in fact, only maintained by the piano-forte, which is essentially the instrument of the temperate scale, and the defects of which have greatly tended to obscure pure melody. The quality or timbre of musical sounds, both vocal and instrumental, is then referred to, and the methods of investigating the vibrations are given, as well as the laws of harmonics and chords. Finally, Italian and German music are compared. The influence of Paris on music, though the French have never been creators, is defined as insisting on the creation of a type of music which should contain the good points of the German and Italian schools without their exaggeration. It has maintained the Italian melody and song, but has also adopted the grand choral and orchestral movements of Germany."

THE RACES OF MAN AND THEIR GEOGRAPHICAL DISTRIBUTION. By OSCAR PESCHEL. Translated from the revised German edition. New York: D. Appleton & Co. Pp. 528. Price, $2.25.

THE students of ethnology are to be congratulated on the appearance in English of this admirable manual of ethnological and ethnographical science, which has for some years and in its successive editions been a standard in Germany. While the work is full and systematic, it is at the same time compact and convenient for reading, being a happy medium between the bulky and formidable treatise, and the deficient and unsatisfying compend. Dr. Peschel's work has the great merit of being up to date in the presentation of an extensive and rapidly-developing branch of science, and of dealing fully with those recent and highly-important questions concerning the science of man which have come forward into such prominence in our own generation. The book is exactly what readers of general cultivation require to inform themselves upon a subject of great moment, and which is occupying the close attention of thinkers in all nations; and it will also be of a special value to the scientific students of ethnology, not only for the breadth and care of its discussions, and the immense amount of information condensed in its text, but also for the copious wealth of its references to the literature and authorities of the subject.

No just idea of its broad range of interesting topics pertaining to the nature, characters, habits, and diversities of man, can be conveyed in a brief notice of the work. But, as its materials are derived from the most instructive portions of history, from the descriptions of races furnished by travelers, from wide geographical observation, and from the various sciences which illustrate the constitution of man and his intercourse with surrounding Nature, the facts brought forward have a very wide diversity of interest, so that we cannot dip into the volume anywhere without becoming quickly absorbed in the question under consideration.

The book is divided into two parts. In the introduction to the first part the author devotes himself to the question of man's place in creation, of the unity or plurality of the human race, of the place of its origin and the problem of its antiquity; then follows a series of disquisitions on the physical characters and the linguistic characters of man, and the industrial, social, and religious phases of his development. The second part is descriptive of the races of mankind, which are taken up in their leading divisions, and in their geographical distribution, and considered with as much detail as the limits of the work will allow. The book, of course, has nothing like the comprehensiveness or strictness of method and classification that characterizes Mr. Spencer's great work, "Descriptive Sociology;" nor has it the depth and completeness of analysis of social phenomena that mark the "Principles of Sociology" by the same author; but, as a *résumé* of the subject in a single handy volume, we have probably nothing so good in the language.

REPORT OF THE GEOLOGICAL SURVEY OF OHIO. Published by authority of the Legislature of Ohio. 4 vols. Columbus: Nevins & Myers, State Printers.

THE first geological information obtained concerning the State of Ohio was derived from a report made by a committee which took its observations in the summer of 1836. Geology was then a science in a preliminary stage of development, and the application of the existing knowledge was impeded by ignorance of the general outlines of the country. Paleontology was in much greater obscurity, and it is natural that the report of that period should seem imperfect at the present time.

In March, 1869, the Legislature passed a bill authorizing a complete survey of the State by a committee of competent men. In addition to a minute geological investigation, they were to make a careful chemical analysis, including a classification of the various soils, and the best means for promoting their utility; and were to take observations to determine the local causes producing variations of climate, etc.

The officers appointed were Prof. J. S. Newberry, chief geologist; Edward Orton and E. B. Andrews, assistant geologists; T. G. Wormley, chemist; F. B. Meek, paleontologist, besides a number of local assistants. They entered upon their work June 1, 1869, and finished it June 1, 1874, at a cost of $256,000, including the publication of four volumes of reports. For rapidity of action, thoroughness of results, and moderation in the expense, this survey contrasts most favorably with those made in other States. Thus far there have been published two volumes on geology and two on paleontology, with maps of some of the counties. In the volumes on paleontology there are a large number of plates and illustrations, which are admirable specimens of careful work and beauty. Ohio is rich in fossil remains, having contributed largely to the cabinets of other States, and this is the first occasion on which they have been presented to the public. The plan of the corps was to publish six volumes, two on geology, two on paleontology, one on economic geology, and one on zoölogy, botany, and agriculture. The last two volumes have not yet been published, though the work of composition is far advanced.

Surveys had been made previous to this one in many of the other States, which presented discrepancies that had given rise to much bitter discussion. It was, therefore, of importance that Ohio should be thoroughly explored, as it formed the key-stone in the arch reaching from the Alleghanies to the Mississippi, and offered the probable means of solving the perplexing difficulties.

According to Prof. Newberry, "the topographical features may be described as those of a plain slightly raised along a line traversing it from northeast to southwest, and worn in the lapse of time by the draining streams into broad valleys, which impart a pleasing variety to the surface, afford free and healthful drainage, and yet leave unimpaired all the productiveness of its original monotony; in fact, exhibiting perhaps the most perfect adaptation to the wants of man which any surface affected by such climatic influences can present." The climate is one of extremes. The soil over much more than half the State is of foreign origin, being transported by Drift agencies frequently from a great distance. The physical substructure is not simple like the surface, but is diversified in different places, both as to the number, character, and thickness of the strata, and the position which they occupy relative to each other and to the horizon. The coal-measures underlie the surface of the southeastern third of the State, there being an aggregate of about 12,000 square miles over which the coal is unequally distributed. All the coals are classed as bituminous, and are divided into dry or furnace coals, coking-coals, and cannel-coals, by far the greater portion being of the coking variety. It is proposed to discuss the distribution, qualities, and uses of the coals in the volume on economic geology.

Manual of the Vertebrates of the Northern United States, including the District east of the Mississippi River and north of North Carolina and Tennessee, exclusive of Marine Species. By **David Starr Jordan**, M. S., M. D., Professor of Natural History in N. W. C. University, and in Indiana State Medical College. Chicago: Jansen, McClurg & Co. 12mo, pp. 342. Price, $2.00.

The object of this work is to facilitate the classification of vertebrate animals by means of artificial keys, such as have been used in the study of botany. It has been prepared for the use of collectors and students who are not specialists, and has been compressed within the narrowest limits in order to render it as cheap a handbook as possible. There are descriptions of 817 species, representing 116 families. It is the only work containing arranged descriptions of the reptiles and fresh-water fishes of this country.

The Centennial Situation of Woman. A Commencement Address at Mount Holyoke Seminary, by Hon. **Alexander Bullock**. Charles Hamilton, Worcester, Massachusetts. Pp. 45.

Governor Bullock made an eloquent speech to the South Hadley ladies, but whether he was quite equal to the occasion may be a question depending upon the view taken of the duties of such an opportunity. Some may think that, in reviewing a hundred years of progress in public or social affairs, it is most suitable to take note of what has been gained; to dwell upon the triumphs, the causes of congratulation, and give indulgence to the more complacent feelings. Others may regard it as the most fitting time to be on our guard against this ever-besetting tendency, the time to survey closely and critically the position that has been reached, to sift current claims, to look sharply after mistakes, and utilize an impressive occasion to forecast the best course of action for the future. Governor Bullock took the most agreeable alternative, and discoursed pleasantly, and with commendable gallantry, of what woman has done to improve her condition in various ways, and what civilization has accomplished for her in furtherance of the same end. He points out the progress that woman has made toward the independence of self-dependence through the opening to her of modern industries; sketches the changes that have taken place in the recognition of her civil rights; and dwells upon the great advance that has been made in the work of female elevation, and in opening to woman a wide opportunity in the vocation of teaching. He touches lightly the vexed question of the intellectual equality of the sexes, saying it has been settled that there is no question at all about it, and deftly quotes a woman—Mrs. Jameson—as expressing the opinion that "the intellect of woman bears the same relation to that of man as her physical organization; it is inferior in power and different in kind. In men the intellectual faculties exist more self-poised and self-directed, more independent of the rest of the character, than we find them in women, with whom talent, however predominant, is in much greater degree modified by the sympathies and by moral causes." The Governor evades the question of suffrage for woman, but is adverse to her participation in public affairs. He cites Franklin as saying that "women should not meddle with party politics, except in the endeavor to reconcile their husbands, brothers, and friends, who happen to be of contrary sides;" and he reminds the listening ladies of the pleasantry of Addison, who remarked: "There is nothing so bad for the face as party zeal. It gives an ill-natured cast to the eye, and a disagreeable sourness to the look; besides that, it makes the lines too strong, and flushes them more than brandy."

THE KINEMATICS OF MACHINERY: Outlines of a Theory of Machines. By F. REULEAUX, Member of the Royal Trade Commission. Translated and edited by ALEXANDER B. W. KENNEDY, C. E., Professor of Civil and Mechanical Engineering in University College, London. With numerous Illustrations. London: Macmillan & Co. Pp. 622. Price, $7.50.

THE number of inventions during recent years has been so great that it is almost impossible to classify the different machines, or to observe any regular system connecting them. This country possesses no systematized instruction or extended literature in regard to machinery, and, although it has been peculiarly rich in inventions, the results would undoubtedly have been more satisfactory if they had been effected according to an arranged method. In this book the theoretical part of machinery alone is treated. The author attempts to give a thorough understanding of its essential nature, by which problems previously unsolvable may be made clear, and by which greater practical results may be reached. In his own words, his purpose is "to determine the conditions which are common to all machines in order to decide what it is, among its great variety of forms, that essentially constitutes a machine. . . . The book is intended, not so much to add to the positive knowledge of the mechanician, as to increase his understanding of what he already knows, so that it may become more 'thoroughly his own property.'" In the old books, each machine was taken up as a whole, and treated by itself. But, as it was discovered that similar parts occur in different machines, the method continually grew more simple. Prof. Reuleaux endeavors to place the science in a position in which it may become deductive, and in which the study may depend upon a few fundamental truths. With him, motion is but a change of position, and the changes are conditioned simply by the geometric form of the moving bodies.

In this volume fluids also take their place as forming a part of machinery, and instances are given in what forms engineers may use them to the greatest advantage. The work, which was written in German, has been published in Italian, and is now being translated into French.

THE ETHICS OF BENEDICT DE SPINOZA. From the Latin, with an Introductory Sketch of his Life and Writings. New York: Van Nostrand. Pp. 375. Price, $3.00.

THIS volume has a peculiar interest in being the first American translation of the "Ethics" offered to the public. As it has been preceded by only one English translation, the book will supply a want in this country, and meet the demand of those who desire to obtain a clear idea of Spinoza's philosophy. The object which Spinoza had, in developing his system, was to discover certain rules by which he might govern his own actions. To accomplish this, he begins with a number of definitions and axioms from which his principles are evolved in regular geometrical order. The work is divided into five parts. In the first part is set forth his conception of God—an absolutely Infinite Being or substance, without beginning or end, and *causa sui.* Nothing can be thought of outside of God, and everything which exists does so through God. In the second part are treated the origin and nature of the human mind and soul. In the third, fourth, and fifth parts, an investigation is made of the passions, their causes and effects, their force and the manner in which they should be governed. The end arrived at is, that the pleasures of sense and intellect should balance each other, and in this manner the greatest happiness be secured. Thus, by a different process of reasoning, he arrives at a result similar to that reached by the Christian religion. Whatever may be thought of this as a religious or logical system, yet, taken as a whole, it is a work of the purest morality. The "Ethics" is the product of the reasoning powers and not of the imagination. Its general style and literary character are at great variance with the smooth disquisitions of modern times, but, if these mechanical effects are overlooked, the thoughtful reader will find the truths as new and striking as when they were first written.

In the preface is given an outline of the author's life, with the effect produced by his writings. The translation has been made with care and skill, and differs from the English translation in being somewhat more concise, while it is at the same time equally clear.

COMPARATIVE ZOÖLOGY, STRUCTURAL AND SYSTEMATIC. For Use in Schools and Colleges. By JAMES ORTON, A. M., Professor of Natural History in Vassar College; Corresponding Member. of the Academy of Natural Sciences, Philadelphia, and of the Lyceum of Natural History, New York; author of "The Andes and the Amazon," etc. New York: Harper & Brothers, 1876. Price, $3.00.

THIS volume, as we are informed by the author in the preface, is "designed solely as a manual for instruction, and to present clearly, and in a somewhat new form, the established facts and principles of zoölogy." It is claimed for it "that the selection and arrangement of essential principles and typical illustrations are from the standpoint of the teacher. . . . and that a distinctive character of the work consists in treating of the whole animal kingdom as a unit, and in the comparative study of the development and variation of organs and functions from the simplest to the most complex state."

The work is divided into two parts, the first of which treats of structure, the second of systematic zoölogy, the plan of the author being to withhold from students the study of the classification of animals until "they have mastered those structural affinities upon which true classification is founded."

In both divisions of the work the synthetic method is employed, as being the most natural one, a study of simple structures and forms being first introduced.

The plan of the work is comprehensive, and claims to represent the latest phases of the science of zoölogy. Comparative zoölogy is defined as "the comparison of the anatomy and physiology of all animals existing and extinct, to discover the fundamental likeness underneath the superficial differences, and to trace the adaptation of organs to the habits and spheres of life."

The style is usually clear and attractive, and the book may be read with interest and profit by others than teachers and students. But we notice some passages which are obscure from brevity, others from inadvertence; and there are several inaccuracies, all of which it will be found more easy to correct in a second edition than it was to avoid in the first.

One feature of the work will neither be overlooked nor excused by naturalists. Of about 350 illustrations, a very large number, probably 300, are old, and have done service several times before. If some of these cuts are excellent and appropriate, others could have been omitted without detriment, while new ones illustrating American types are needed.

The value of the work is enhanced by copious notes, 220 in number, at the close of the volume.

WHAT YOUNG PEOPLE SHOULD KNOW. The Reproductive Function in Man and the Lower Animals. By BURT G. WILDER. With Twenty-six Illustrations. Boston: Estes & Lauriat. Pp. 212. Price, $1.50.

PROF. WILDER, being convinced that there are greater evils caused by ignorance of the legitimate and illegitimate uses of the reproductive organs than by the perversion of any other human propensity, has written this book to dispel the ignorance. If there were real knowledge upon such subjects, he thinks there would be no exercise of the imagination in regard to them. Few will agree with him in this idea, however excellent his work may be as a physiological treatise for the young in this special branch.

Practical Botany, Structural and Systematic, etc. By August Koehler, M. D., Professor of Botany in the College of Pharmacy of the City of New York. Copiously illustrated. New York: Henry Holt & Co. 12mo, pp. 400. Price, $3.00.

The author, believing that "the study of botany cannot become truly profitable until a number of plants have been identified by the student, and their images received into his memory," has constructed a book which is an artificial key to "stimulate the unlearned," and act as a labor-saver to those already somewhat acquainted with the science. It departs from the ordinary system of classification, in being arranged according to the old dichotomal method. The natural tendency of this might, perhaps, be to suggest names rather than the association of principles. Those, however, who are desirous of rapid action, and speedy results, will find here a book for their purpose in a neat and convenient form.

Theory of Medical Science: The Doctrine of an Inherent Power in Medicine a Fallacy. The Ultimate Special Properties of Vitality and the Laws of Vital Force constitute the Fundamental Basis of Medical Philosophy and Science. By William R. Dunham, M. D. Boston: James Campbell. Pp. 150. Price, $1.25.

The title-page speaks for itself, and indicates the theory on which this book was written. The work was published with the hope that it might recover the "fundamental principles involved in a correct theory of medical science," assist the profession in the details of practice, and enable the non-professional to distinguish between quackery and rational practice. The author finds fault with the medical profession because it continues to follow the ancient interpretations of the science, but seems unwilling himself to adopt the results of those who are doing most for the furtherance of correct principles in regard to mind and body.

California Notes. By Charles B. Turrill. San Francisco: Bosqui & Co. Price, $1.50.

The "Notes" is a description or guide through different sections of California, in which the author conducts his readers to the places visited by him. Among the subjects represented in the book are, "San Francisco," "Into the Heart of the Foot-Hills," "Calaveras County," "Gold-Mines," "The Yosemite Valley," etc. This volume is the initial number of a series.

Elements of Physical Manipulation. By Edward C. Pickering, Thayer Professor of Physics in the Massachusetts Institute of Technology. Part II., pp. 316. Price, both parts, $4.00.

This second volume, like the first, is designed as a special text-book for the laboratory. The text is made up principally of experiments, giving a description of the instruments to be used, and a plan of what is to be done. Among the subjects discussed are "Electricity," "Meteorology," and "Astronomy." The latter is a new feature in laboratory practice, but there is no reason why it should not be taught practically, as well as chemistry or physics.

PUBLICATIONS RECEIVED.

The Religion of Evolution. By M. J. Savage. Pp. 253. Boston: Lockwood, Brooks & Co. Price, $1.50.

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MISCELLANY.

Distribution of Plain, Prairie, and Forest.—In the *American Naturalist* for October, Prof. J. D. Whitney gives a very elaborate critique of the various hypotheses which have been put forth to account for the distribution of plain, prairie, and forest, over the North American Continent. The author has no theory of his own to offer, but he appears to show conclusively that none of the accepted theories can be regarded as satisfactory. One of the theories examined by Prof. Whitney is that which attributes the existence of forest, prairie, or plain, to the distribution of rainfall throughout the year, or from season to season. As stated by the late J. W. Foster, this theory holds that "wherever the moisture is equable and abundant, we have the densely-clothed forest; wherever it is unequally distributed, we have the grassy plain (prairie); and where it is mostly withheld, we have the inhospitable desert." This last proposition Prof. Whitney admits, the other two he pronounces erroneous. He cites the vicinity of Chicago, where Mr. Foster lived, in proof of the incorrectness of that author's views. "Here," says Prof. Whitney, "we have the finest prairie-regions in the world, absolutely destitute of trees, and yet in the full enjoyment of an abundant precipitation, and in the immediate vicinity of an immense sheet of water. For Chicago itself, indeed, the statistics of rainfall are very defective, but, such as they are, they are entirely unfavorable to Mr. Foster's hypothesis. Points in the immediate vicinity of that city, where observations have been taken for a series of years, show an average rainfall of thirty-six to fifty inches, pretty uniformly distributed through the year. An excellent instance, on the other hand, of a dense growth of trees combined with the most unequally-distributed rainfall which is possible, is furnished by the western slope of the Sierra Nevada, in California, whose magnificent forests are well known, as also is the fact that there is no precipitation there at all for six months of the year, nearly the whole of the rainfall being limited to three months. And, lest it may be thought that melting snow keeps the ground moist during the summer, it may be added that the heaviest forest-belt of the Sierra is quite below the line above which snow rests for any considerable time, and that the soil in that belt is usually perfectly dry at the surface, and even dusty, for six months of the year, and often much more."

Electrical Phenomena exhibited by Venus's Fly-Trap.—The electrical phenomena exhibited by *Dionæa muscipula* have been investigated by Dr. Burdon-Sanderson, who finds that normally the whole leaf with the petiole is somewhat negative, but, when excited by a stimulus, an electrical change takes place throughout, making every part more negative. The greatest change is on the external surface of the leaf, immediately opposite to the three sensitive hairs. There is no relation between the preëxisting currents and the electrical disturbance consequent on stimulation. The period of latent stimulation (i. e., the space of time occupied by the primary action of the stimulus) is about one-sixth of a second. The period during which the disturbance lasts is about one second. As the leaf becomes fatigued, the period of latency increases to one second and three-quarters, and then most likely the next stimulation produces no effect. The change appears to be a function of the protoplasm of the parenchyma of the region out of which the sensitive hairs arise. Certain of the characters of the change are similar to those presented by muscle and nerve. Why the variation should be a negative one, Dr. Sanderson is unable to determine.

New Shells from Colorado.—In the extensive and remarkable display of natural-history objects brought to the Centennial Exhibition by Mrs. M. H. Maxwell, of Boulder, Colorado, was a box of land and fresh-water shells. These have been examined by Mr. Ernest Ingersoll, who made careful studies of the Rocky Mountain mollusks in connection with the United States Geological Survey in 1874, and summarized his results in an article printed in this magazine for May, 1876. Boulder is at the mouth of Boulder Cañon, several miles northeast of Denver, at an altitude of about 5,530 feet above the sea, and on the eastern slope of the main range, where heretofore no shells had been found. The list includes *Zonites arboreus*, *Z. fulvus*, *Patula Cooperi* (living, and very dark and fine), *P. striatella*, *Helix pulchella*, *Cionella subcylindrica*, *Vertigo* ——? (very minute), *Succinea lineata*, *S. Nuttalliana*, *Limnea palustris*, *L. desidiosa*, *L. humilis*, *Physa heterostropha*, *Planorbis bicarinatus*, *P. tumens*, *Helisoma plexata*, *Gyranlus parvus*, *Ancylus* ——?, *Goniabasis livescens*, *G. pulchella*, *Sphærium striatinum*, *Pisidium abditum*, and an anodon hardly identifiable.

The collection is remarkable, as coming from the eastern slope of the range, and embracing some unexpected species from east and west. As usual, the *Physas* are *Protean* in form, and one can make half a dozen "species" out of them, if disposed. Some of them are well-marked "*Inflata*." Both the planorbs are reported for the first time from Colorado. *P. bicarinatus* is a well-known Eastern shell; *P. tumens* has hitherto been supposed to be confined to Northern Mexico and Southern California. The *Helisoma* is a new form, discovered by Mr. Ingersoll in an isolated mountain-lake in the southern part of the State, and Mrs. Maxwell finds it at Boulder in a similar situation. Both the *Melanians* and the *Sphærium* are additions to the fauna of the State, and the *Anodonta* will probably prove to be undescribed. Mrs. Maxwell proposes to search still more carefully when she returns, and further information on the geographical distribution of our mollusks in the mountainous territories may be expected from various other quarters where research has been stimulated by the curious results already brought out. Colorado seems to be a meeting-ground for mollusks from all directions, and is a promising field for the collector and student.

Marey's Experiments on the Action of the Heart.—Experiments made by Marey show that a diminution of excitability and a rise of temperature in the muscular tissue of the heart invariably coincide with the cardiac systole, while the opposite phenomena are manifested during diastole. The same author has recently attempted to ascertain whether any corresponding variations of the cardiac muscle could be made out. The galvanometer, owing to the inertia of its needle, is unsuitable for the observation of sudden changes in the intensity of currents. Hence, in Marey's experiments, Lippmann's electrometer was employed. The heart of a frog was placed on two unpolarizable electrodes, one supporting the apex of the ventricle, while the auricles rested on the other. Two successive negative variations of the current were indicated by the electrometer during each cardiac systole; one of these was sudden, and corresponded with the abrupt contraction of the auricles; the other was more gradual, and coincided with the slower movement of the ventricle. The phases of electrical variation are thus seen to be similar to those of the work done by the muscle.

College Exploring Expeditions. — We learn from the *Tribune* that the present Senior Class of Princeton College has organized a scientific exploring expedition to the West. An association has been formed to train men in scientific studies, and fit them as far as possible for the work to be done. The plan of the association's work is as follows: A knowledge of geology, as good as can be obtained, is required of each man. Then the work is mapped out into subdivisions of natural history and paleontology, and from these each one selects a specialty for himself. The meetings are held fortnightly. At these, the association generally receives an address from some scientific member of the faculty. After this, scientific papers are read by the members, in alphabetical order, four each evening. A question chosen at the previous meeting is then discussed. The faculty have given a room, have arranged the studies to help the association as much as possible, and given facilities for special and outside work. The association is forming a working collection of fossils and minerals, not intended to be complete, but typical. In the mean time the executive committee are taking steps to secure government aid in the shape of wagons, mules, etc., and to get the most favorable possible terms from the railroad companies. If, as is hoped, the committee is successful in obtaining free passes, the expenses will probably not exceed $100 per man. It is not yet fully determined what portion of the West will be explored—probably, however, the Green River, in Wyoming Territory, and Yellowstone National Park, or else the Wahsatch Mountains, will be selected. The membership is limited to thirty regular and ten alternate members. Vacancies occurring in the regular membership are filled from the alternates, who attend all meetings, and perform regular duties.

Eucalyptus as an Anti-Periodic.—Two instances are cited by Dr. Curnow, of London, of the cure of intermittent fever by the use of tincture of *Eucalyptus globulus*. We give in full the author's account of one of these cases, as sufficiently illustrating the action of the drug: S. S——, aged eighteen, a Norwegian, was admitted to King's College Hospital, May 23, 1876. He had been suffering from intermittent fever for four or five weeks. The attacks were moderately severe and of a well-marked tertian type. An expectant plan of treatment was pursued until June 9th, and during this period the paroxysms recurred on alternate days with the utmost regularity. They began at 10 A. M., reached their acme between 1.30 and 3 P. M., and passed off about 6 P. M. The highest temperatures varied from 104.8° to 105.6°. On June 9th the tincture of the *Eucalyptus globulus* was given in one-drachm doses three times daily. The next day, on which another attack was due, his temperature rose to 100°, and on the 12th to 100.4°; and after this date no further paroxysm occurred during the remainder of his stay in the hospital.

Improvements in Iron-Manufacture.—Dr. Andrews, in his inaugural address at the Glasgow meeting of the British Association, referred to the many improvements recently introduced in iron-manufacture. But there yet remains, he said, ample work to be done. The fuel consumed in the manufacture of iron, as indeed in every furnace in which coal is used, is greatly in excess of what theory indicates, and the clouds of smoke which darken the atmosphere of English manufacturing towns, and even of whole districts of country, are a clear indication of the waste, but only of a small portion of the waste, arising from imperfect combustion. The depressing effect of this atmosphere upon the working-population can scarcely be overrated. At some future day the efforts of science to isolate, by a cheap and available process, the oxygen of the air for industrial purposes, may be rewarded with success. The effect of such a discovery would be to reduce the consumption of fuel to a fraction of its present amount; and, though the carbonic acid would remain, the smoke and carbonic oxide would disappear. In the mean time, Dr. Andrews suggests that in many localities the waste products of the furnace might be carried to a distance by a few horizontal flues of large dimensions, terminating in lofty chimneys on a hillside or distant plain, as is done at the mercury-mines of Idria and some other places. With a little care in the arrangements, the smoke would be wholly deposited in the horizontal flues, and would be available for agricultural uses.

The Tomato - Plant as a Protection against Insects.—In a peach-orchard planted by M. Siroy, a member of the Valparaiso Society of Horticulture, the trees at first grew well and strongly. But, on commencing to bud, they were invaded by the curculio; and this insect was followed, as frequently happens, by ants. While the trees were thus infested, the idea occurred to M. Siroy that by placing leaves around the trunks and branches he might ward off the rays of the sun, which were very powerful. For this purpose he happened to choose tomato-leaves. On the following day he found the trees entirely free from their enemies, not one remaining, except here and there where a curled leaf prevented the tomato from exercising its influence. These leaves he carefully unrolled, placing upon them fresh ones from the tomato-vine, with the result of banishing the last insect, and enabling the trees to grow with luxuriance. Wishing to carry the experiment still further, he steeped in water some fresh leaves of the tomato, and sprinkled with this infusion other plants, roses and oranges. In two days these were also free from the innumerable insects which covered them.

The Age of Paleolithic Man.—Dr. R. H. Tiddeman contributes to *Nature* for October 5th a paper in which he reaffirms the inter-glacial age of paleolithic man and of the fauna with which he is associated. The position not only of human but of animal remains points clearly to the fact of their existence subsequent to a deposit of glacial drift, but previous to another deposit of similar material. The facts may be taken as part of the evidence which proves the disappearance of a great ice-sheet which covered Scotland, England, and portions of the Continent, and the return of it after a period of temperate climate during which man and animals inhabited the region.

The direct evidences of the inter-glacial age of paleolithic man from the actual infraposition of his bones or implements are stated as follows:

1. Victoria Cave, Settle: *a human fibula* under glacial till, and associated with bones of *Elephas antiquus*, *Rhinoceros leptorhinus*, hyena, hippopotamus, etc.

2. At Wetzikon, Canton Zürich, a piece of lignite containing *basket-work* lying beneath glacial deposits, and associated with *Elephas antiquus* and *Rhinoceros leptorhinus*.

3. Near Brandon, Suffolk, *implements* with bones not yet determined in brick-earth beneath the great chalky bowlder-clay of East Anglia.

Dr. Tiddeman says the "Settle till is undoubtedly of the age of the ice-sheet. The Wetzikon lignite lies upon a glacial till beneath a river-gravel on which are great erratic blocks clearly indicating the presence of a great glacier posterior in date to the organic remains. The Brandon implements are beneath the chalky bowlder-clay."

Inequality of the Ocean-Bed.—In opening the Geographical Section of the British Association at Glasgow, Captain Evans said that it was learned for the first time by the Challenger's results—ably supplemented as they had recently been by the action of the United States Government in the Pacific, and by an admirable series of soundings made in the exploratory German ship-of-war Gazelle—that the unbroken range of ocean in the southern hemisphere was much shallower than the northern seas; that it had no features approaching in character those grand abysmal depths of 27,000 and 23,500 feet found respectively in the North Pacific and North Atlantic Oceans, as the greatest reliable depths recorded did not exceed 17,000 feet. The general surface of the sea-bed presented in general to the eye, when graphically rendered on charts by contour lines of equal soundings, extensive plateaux varied with the gentlest of undulations. There was one great feature common to all oceans, and which may have some significance in the consideration of ocean circulation, and as affecting the genesis and translation of the great tidal wave and other tidal phenomena, of which they knew so little—namely, that the fringe of the seaboard of the great continents and islands, from the depth of a few hundred feet below the sea-level, was, as a rule, abruptly precipitous to depths of 10,000 and 12,000 feet. This grand escarpment was typically illustrated at the entrance of the British Channel, where the distance between a depth of 600 feet and 12,000 feet was in places only ten miles. Imagination could scarcely realize the stupendous marginal features of this common surface depression.

Purification and Deodorization of Petroleum Products.—Mr. S. E. Johnson, of Ashby-de-la-Zouch, England, has discovered a method of treating petroleum and other mineral oils, by which those useful hydrocarbon liquids are not only purified, but also deodorized; and that in a simple and inexpensive manner. Chloride of lime is first introduced into the cask or other receptacle containing mineral oil or spirit, in the proportion of about three ounces of chloride, more or less, to each gallon of the liquid, according to the degree of its impurity, and thus chlorine-gas is evolved in the oil or spirit. If necessary, the evolution of the gas may be assisted by pouring in hydrochloric acid, agitating the contents of the receptacle so as to bring the whole of the liquid into intimate contact with the chlorine-gas. The oil or spirit is then passed into another inclosed vessel containing slaked lime, which, having an affinity for the chlorine, absorbs the same, leaving the liquid sufficiently deodorized and purified.

Physiological Effects of Coca.—A correspondent of the *Lancet*, a physician, states that the use of the tincture of coca, in a two-ounce dose, corrected the "unruly throbbing" of his heart, which had been wont to interfere with his accuracy of aim in fowling. This writer had previously taken the tincture in doses of one-half ounce and one ounce without perceptible effect; but, having on the third day increased the dose to two ounces, his composure was perfect at the critical moment. "As soon as the dogs pointed," he writes, "I expected the usual inward commotion, with its usual results; but, to my surprise, nothing of the kind happened. 'Eureka!' I said to myself; 'the coca has made me a steady shot.' So in fact it subsequently proved. Judged by the effects described," he continues, "coca would seem to be inhibitory as regards the action of the heart. Whether this result is produced by indirect action through the mental functions upon which the drug is said to act remains to be proved." Another correspondent of the same journal, not a physician, states that while traveling in Bolivia at great altitudes, such as from 13,000 to 14,000 feet above the sea-level, he experienced marked benefit from eating the leaves. Nearly all travelers on the Peruvian and Bolivian Andes use the drug as a remedy for that effect on the brain and lungs, produced by rarefied air, which in South America is called *zorroche*. One use to which it is put by the Indians is that of a "pick-me-up" after a debauch on alcoholic fluids. In Bolivia it is generally eaten with a paste made of wood-ashes and potato. The writer propounds the belief that the leaf loses its virtue in transmission. This is quite possible. It is an undoubted fact that the *Cannabis Indica*, for instance, loses its potency in crossing the sea. It would seem desirable that a certain quantity of the coca-leaves should if possible be packed in an air-tight case. The price of coca at La Paz, where the best is procured, was last year sixteen dollars per packet of twenty-five pounds.

The American Forestry Association.—The American Forestry Association held its first meeting at Philadelphia in September. Addresses were delivered by Dr. Franklin B. Hough, of Lowville, New York, Mr. McAfee, and Mr. Meehan. Dr. Hough gave an account of the efforts made by various European governments to preserve forests and to promote timber-culture, and showed that the Constitution of the United States, and those of most of the States, give the right to interfere for the preservation of our forests. Mr. McAfee reported on the condition of forest-culture in the West, showing how the planting of trees had been going on to an immense extent, and that it was found that the old notions about the slowness of timber-growth had been derived from the hard struggle with Nature that wild timber had to make. Cultivated trees had grown so much faster than was expected that people had been surprised at the growth, and it was now becoming generally known that wood came into profit much sooner than was thought possible years ago, and forest-culture was much more popular in consequence. In his State at least 80,000 acres of timber had been planted during the past few years, and the work was still going on. He gave figures as to the growth of individual species, chiefly from facts within his own observation. Mr. Meehan, from whose *Gardener's Monthly* we take this account of the meeting, thought that the people, without government interference, can be safely trusted with the care of our forests, and the work of reforestation. Individual effort, encouraged by State laws and agricultural and horticultural societies, would soon replace the decaying forests of our land.

How the Menopoma casts its Skin.—Since reading his "Preliminary Note on the *Menopoma Alleghaniense* of Harlan," before the American Association, Grote has observed in the aquarium of the Buffalo Society of Natural Sciences the process by which the menopoma rids itself of its outer skin. This thin and transparent membrane is first seen to loosen and separate from the entire surface of the body, appearing at this stage like an envelope or glove in which the animal is contained. By a number of wide gapings, during which the mouth is opened to the fullest extent, the skin is parted about the lips, and then commences to fold backward from the head. Convulsive and undulating movements with the body and fore-legs are employed to extract these from the loose skin. The skin then readily falls backward, as the animal crawls forward and out of it, until the hind-legs are reached, when the menopoma turns round upon itself, and, taking the skin in its mouth, pulls it over the legs and tail. The operation reminds one of taking off clothes. The cast-off skin is retained in the mouth and finally swallowed. The operation is quickly performed.

Poisonous Cooking-Utensils.—The danger attending the use of porcelain-lined cooking-vessels was pointed out at a meeting of the British Society of Public Analysts, by Mr. Robert R. Tatlock. He stated that the milk-white porcelain enamel with which cast-iron cooking-vessels are now so commonly coated is in the highest degree objectionable, on account of the easy action on it of acid fruits, common salt, and other substances, by means of which lead and even arsenic are dissolved out in large quantity during the process of cooking. It was shown that it is not so much on account of the presence of large proportions of lead and arsenic that these enamels are dangerous, but because they are so highly basic in their character, and are so readily acted on by feebly-acid solutions. He thought that no enamel should be admitted to use unless it was totally unaffected by boiling with a one-per-cent. solution of citric acid, which was a very moderate test. Further, he gave it as his opinion that either the use of such poisonous ingredients as lead and arsenic in large quantity should be entirely discontinued, or that the composition otherwise should be of such a character as to insure that none of the poisonous substances could be dissolved out under ordinary circumstances.

Agencies that formed the Colorado Cañons.—The great cañon of the Colorado is from 3,000 to 6,000 feet deep, through a distance of 200 miles. All the side-streams reach it through profound cañons, and each stream has done, and is still doing, its own work of erosion. The process by which these results are brought about is considered by Prof. G. R. Gilbert, in the *American Journal of Science and Arts*, under three principal heads: 1. Weathering; 2. Transportation; 3. Corrasion.

By weathering, the writer means the disintegration of rock by the action of temperature—beating of rain and changes of vegetation. The process, however, would be greatly delayed if the loosened material was allowed to remain and cover the surface. Hence transportation becomes a powerful agent in erosion, not only by exposing the disintegrating surfaces, but by mechanical wear in the act of removal.

All rocks are more or less soluble in water, and impurities in the water intensify solvent action. But it usually happens that rocks disintegrated in this way merely fall to pieces, the hard portion remaining in the shape of sand or pebbles. The transportation of this by streams produces what the author calls *corrasion*. In this way the bed of a stream is widened and deepened, but the work is also facilitated by the ceaseless action of water in dissolving the rocks.

The mechanical wear or erosion by a stream depends largely on its velocity. "A stream of water flowing down its bed expends an amount of energy that may be measured by the quantity of water and the vertical distance through which it descends."

The velocity of a stream would continually increase if none of its energy was consumed in friction, but very much of it is so consumed, and reappears in innumerable forms of movement or subsidiary currents. It is by some of these that the work of transportation and erosion is largely done. But a stream may be overloaded with detritus, and its corrading power correspondingly diminished. "Only with a partial load does a stream wear its bottom." Of the Colorado plateau the author says that the erosion which began with the first lifting of a part above the ocean has progressed continually to the present time. The total uplift has been about 12,000 feet; only 7,000 feet remains, that being the present altitude above the level of the sea. Five thousand feet of the general surface has been removed, and an amount greater by several thousand feet has been corraded by the rivers.

Improved Railway-Signal.—A simple and effective railroad-signal, in use on the Boston, Lowell & Nashua Railroad, is described in the *Scientific American*. A single-cell Callaud battery is connected to the two rails at one end of a given section of the line—say, two miles in length—each section being insulated from adjoining sections. At the other end the signal has an electro-magnet similarly connected to the two rails. When the circuit is closed, as is normally the case, the magnet is excited and the signal controlled thereby so as to show that the line is clear. But, when a train runs on the section, then a shorter circuit is made by the wheels and axles, and the current returns to the battery by this course, instead of passing through the signals. The magnet ceases to attract, and the signal by mechanical means is at once turned, to indicate danger. It is obvious that this must occur as long as a single car remains on the track, or when the circuit is broken by a displaced or ruptured rail or any other cause. Hence the device may be applied over an entire line, and will indicate the condition of every section to a train about to enter on the same. It is found to be operative in all weathers.

Powder-Paper.—A substitute for gunpowder has been invented in England, called "powder-paper," viz., paper impregnated with a mixture of potassic chlorate, nitrate, prussiate, and chromate, powdered wood-charcoal, and a little starch. The powder-paper is rolled into the shape of a cartridge of any required length or diameter. The manufacture involves no danger, it is said; no explosion can take place except by way of contact with fire. The powder-paper leaves no greasy residue on the inside of the gun; it also produces less smoke, gives a less violent recoil, and is less impaired by humidity than gunpowder. With equal charges, by weight, of gunpowder and powder-paper, the penetrating power of the latter is $\frac{5}{16}$ greater than that of the former.

October Meteor-Shower.—In a letter to the *Tribune*, dated October 19th, Mr. Daniel Kirkwood states that shooting-stars in unusual abundance were observed by several trustworthy witnesses at Bloomington, Indiana, on the evening of the 18th, from six hours forty-five minutes to nine hours. The meteors appeared to radiate from Auriga, or rather from a point between Taurus and Auriga. Most of the meteors were small, though two of them possessed extraordinary brilliancy. In a small work on comets and meteors, published three years ago, Mr. Kirkwood called attention to the fact that meteoric showers had been observed at the same period of the year in 1436, 1439, 1743, and 1798. Returns of the shower were observed in 1838 and 1841. He recommends that a careful watch be kept in future about the same period—say, from the 16th to the 20th of October.

Do Plants absorb Diatoms?—Prof. John Phin, in the *American Journal of Microscopy*, criticises the results of Wilson's microscopic examination of wheat-straw grown on land which had been treated with infusorial earth. The substance of Prof. Wilson's paper we gave in the September number of the MONTHLY. Prof. Phin reproduces Wilson's engraved representation of the diatom forms said to have been found in the remains of the straw after treatment with nitric acid, and says: "A single glance at the engraving is sufficient to convince any microscopist that Prof. P. B. Wilson never saw 'upon the field of his microscope,' under the circumstances which he has described, the objects which he has delineated. . . . Bearing in mind that these organisms, as figured, have been obtained by destroying the organic matter with nitric acid, we find *Bacillaria* figured as it exists only in the living condition—the frustules being joined together in the peculiar way which has given to this form the specific name *paradoxa*. For this diatom to have passed through a bath of nitric acid, and come out in the condition figured, would have been almost as great a miracle as the passing of Shadrach, Meshach, and Abednego, unscathed through the fiery furnace of Nebuchadnezzar. So, too, we find a *calcareous* foraminifer figured under the same circumstances. After such instances, the numerous minor features which are utterly irreconcilable with facts may be safely passed over."

Another Way of securing the Chestnuts.—The following narrative is taken from the *Chronique de la Société d'Acclimation*; we give it for what it is worth: "A Frenchman, fifteen years resident in the Transvaal Republic, where he has established a number of plantations, recounts to us the following fact, which no naturalist has as yet reported: The coffee-plantations are much exposed to the ravages of the great cynocephalous monkeys. Among the coffee-plants there grows a shrub, the scientific name of which I have not been able to ascertain, which has its fruit growing very near the trunk. Some wasps, of a kind whose sting is very painful, had chosen several of these bushes for attaching to them their eggs, and the cynocephali were often seen eying the fruit very eagerly, but they dared not touch them for fear of the wasps. One morning, the planter heard terrible cries, and with the aid of a good opera-glass was enabled to witness an interesting spectacle. A fat old monkey, the leader of the troop, would take hold of the young ones, and pitch them repeatedly into the middle of the bush, despite their cries and groans. The shock brought down the wasps' nests, and the irate insects attacked the victims; meanwhile the old rogue quietly ate the fruit, throwing down the remnants of the meal to the females and young ones on the ground."

Taking Impressions of Plants.—M. Bertot, of the Paris Academy of Sciences, offers a simple method of taking impressions of plants. A sheet of paper is first lightly oiled on one side, then folded in four, so that the oil may filter through the pores, and the plant may not come into direct contact with the liquid. The plant is placed between the leaves of the second folding, and in this position pressed (through other paper) all over with the hand, so as to make a small quantity of oil adhere to its surface. Then it is taken out and placed carefully on white paper; another sheet is placed above, as two impressions can be taken at once, and the plant is pressed as before. On now removing it, an invisible image remains on the paper. Over this you sprinkle powdered black-lead, which causes the image to appear. With an assortment of colors, the natural colors of plants may be reproduced. To obtain fixity, resin is mixed with the black-lead in small quantity; the impression is fixed when it is exposed to a heat sufficient to melt the resin.

Ancient Weapons.—Among the Michigan exhibits of ancient stone and copper implements at the Philadelphia Exposition is a weapon fashioned after the model of the "patu-patu" of New Zealand. It is described by Dr. C. C. Abbott, in the *American Naturalist*. The patu-patu of New Zealand is, according to Tylor, quoted by Dr. Abbott, "an edged club of bone or stone," in shape "like a soda-water bottle with the bulb flattened. It is a very effective weapon," he adds, "in a hand-to-hand fight, being so sharp that a man's skull may be split at one blow with it." The Michigan specimen is 16¼ inches long. It is 2⅝ inches wide for 11 inches; then it tapers to 1½ inch, but again widens to 2 inches at the end, thus forming a terminal knob. The edges are beautifully wrought, and are as sharp now as most of the polished stone axes and celts. In the vast collection of relics of American aborigines at Philadelphia Dr. Abbott finds no other specimen of the form here described, and it is presumable that this weapon was one seldom fashioned in North America.

NOTES.

A MEETING of persons interested in the formation of a Metrological Society was lately held in Boston, which resulted in the organization of the "American Metric Bureau." Arrangements were made to secure a large list of honorary or life members, and to solicit subscriptions to supply teachers with metric apparatus at half-price. The assessment for 1876 was fixed at $2.50. The list of directors is as follows: Samuel W. Mason, J. P. Putnam, Prof. W. F. Bradbury, Dr. Edward Wigglesworth, Melvil Dewey, Prof. William Watson, Dr. H. P. Bowditch, S. S. Greene, Nathan Appleton, and Prof. K. S. Pennell.

IN the Paris School of Mines is a laboratory, founded in 1845, for analyzing gratuitously any substances presented. Last year 767 analyses were made at this laboratory, chiefly of minerals and manures. A laboratory for the gratuitous analysis of medicines and articles of food would be a very useful institution in our American cities.

CREMATION of the dead is now fairly established in Saxe-Gotha. In a recent sitting of the town council, it was decided to erect the necessary apparatus in the new cemetery. Cremation is to take place only in accordance with the clearly expressed wish of the deceased, and under permit from the proper medical officer. The ashes are to be gathered in urns, to be preserved by the family of the deceased, or set up in a hall in the cemetery.

IN one of the monthly reports of the Department of Agriculture, it is stated that in Livingston County, Illinois, the planting of trees in groves and shelter-belts, and for ornamental purposes, is now very general. The black-walnut is the favorite tree for profit and ease of cultivation; but elm, soft maple, willow, cottonwood, European larch, and ash, are common, while evergreens are popular for ornamental purposes, and occasionally are planted in groves and shelter-belts.

AT the Agricultural Congress in Philadelphia, resolutions were offered by Prof. C. V. Riley, and unanimously adopted, in favor of government action for the suppression of the Rocky Mountains locust-plague. In the opinion of the Congress, the national Legislature owes it to the people of the West to take this matter into consideration, and the United States are called upon to follow the example of other nations under like circumstances, and appoint a special commission for the thorough investigation of the subject.

IN a work on the "Voices of Animals," by Landois, additional evidence is collected of the universality of vocal sounds among the lower animals, including the Mollusca. The author considers it to be indisputable that ants possess a vocal speech, by which they are enabled to exercise those higher mental faculties to which they owe their high social organization.

THE University of Michigan had last year 101 female students, distributed as follows: Medicine, 37; law, 2; homœopathy, 2; literature, 60. "The experience of the past year," writes the president of the university in his annual report, "confirms the opinion we have been led to form by the experience of former years, that women who come here in good health are able to complete our collegiate or professional course of study without detriment to their health."

PROF. MAURICE SCHIFF, of Florence, has demonstrated that the non-edible mushrooms, "toadstools," contain a common poison, *muscarine*, and that its effects are counteracted by either atropine or daturine. Italian apothecaries now keep these drugs in the rural districts, where the consumption of the non-edible fungi is apt to occur. The hint is worthy of attention everywhere.

IT has been affirmed that not less than four per cent. of all the coal-laden vessels that have left English ports during the last five years, for destinations south of the equator, have suffered either total or partial loss by the spontaneous ignition of their cargoes.

At the recent meeting of the British Association, Mr. Garner stated that he had found from measurements of brain capacity, and from casts of the interiors of skulls, that the size of the brain in the dog does not correspond very closely with the size of the animal. No dog has so large a brain as the wolf, nor one so small as the jackal. The brain of a Newfoundland dog is very little larger than that of a terrier. Prof. Macalister, of Dublin, gave an account of the brain of the celebrated greyhound "Master Macgrath." He had weighed the brain of many other dogs, but Master Macgrath's was the heaviest of all, and the convolutions were much more complex.

In a balloon-voyage from Cherbourg, in August, two French aëronauts, Moret and Durnof, observed with surprise, at a height of 1,700 metres, that the bottom of the sea was visible in detail, though that part of the British Channel must have a depth of 60 to 80 metres. The rocks and submarine currents appeared with great distinctness. It is suggested that this fact might be utilized, a means being afforded of giving accurate representations of the bottom for the benefit of navigators.

In the *Scientific Farmer* we find recorded the death of Prof. Dimond, of the New Hampshire Agricultural College. He, no doubt, died of overwork. In the Agricultural College he was Professor of Agriculture, Botany, and Chemistry, farm-superintendent and steward, and at the same time was Professor of Botany and Chemistry in Dartmouth College. It is stated that three men will be appointed to perform the duties recently performed by Prof. Dimond.

During the past year the French Association for the Advancement of Science expended the sum of 7,000 francs in aid of scientific research. Of this sum, 5,000 francs was granted to the astronomer Janssen, to help defray his expenses as a member of the expedition to observe the transit of Venus; and 2,000 francs to M. Chapelas-Coulvier-Gravier, to enable him to continue his observations of shooting-stars.

At one point on the margin of Lake Tanganyika (Central Africa), Captain Cameron saw large masses of coal. In the district adjoining Manyuema iron is plentiful: the people manufacture large quantities of iron, and many of the articles they make are beautifully finished.

Prof. H. N. Martin will lecture on animal physiology, in the John Hopkins University, Baltimore, on Tuesdays and Fridays during the winter. The lectures will be accompanied by instruction in the laboratory. After the spring vacation, Prof Martin will deliver a course of lectures on general biology, intended for elementary students. There will also be organized, during the latter part of the session 1876–'77, a short course of more advanced lectures on embryology.

The formation of nickel-ore near Lancaster, Pennsylvania, is pronounced by the *American Manufacturer* to be the heaviest so far discovered in any part of the globe. The ore is exceedingly rich, of a grayish tint, very heavy, and so hard and closely united to the surrounding substances that it has to be got out by blasting. As soon as the ore is mined, it is crushed into small pieces, and then transferred to kilns of a capacity of from eighty to ninety tons each. It is then subjected to heat obtained at first by burning wood, and which is continued by the conversion of the evaporating fumes. The manipulation is concluded by the fused metal being placed in a smelting-furnace, and undergoing a process similar to that adopted in the treatment of iron-ore.

A Berlin machinist has invented a steam-velocipede. The boiler is heated by means of a petroleum-lamp, and rests on the axle of the hind-wheels.

The Paris correspondent of the London *Times* states that, in digging the new basin at St.-Nazaire, animal remains, tools, weapons, and utensils, have been found in a sandy stratum 20 feet below the surface. Last year a dolichocephalous skull was found near the same spot.

The Registrar-General of Great Britain and Ireland, in his quarterly return, states that the births of 296,350 children, and the deaths of 171,082 persons of both sexes, were registered in the United Kingdom in the three months ending June 30, 1876. The recorded natural increase of population was thus 125,268. The registered number of persons married in the quarter ending March 31, 1876, was 117,760. The resident population of the United Kingdom in the middle of 1876 is estimated at 33,093,439; that of England and Wales at 24,244,010, of Scotland at 3,527,811, and of Ireland at 5,321,618.

Dr. Magnus condemns the use of blue glasses as a protection for the eyes, and prefers the gray and smoky glasses used in England. He considers blue glass specially irritating to the eye, and says that many birds, reptiles, and amphibians, have yellow or reddish oil-drops in the eye to neutralize this blue color and protect the eyes.

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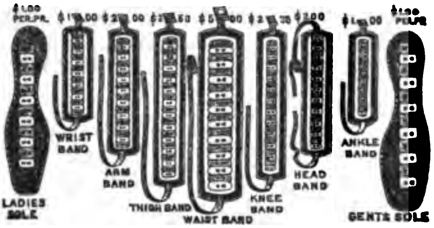

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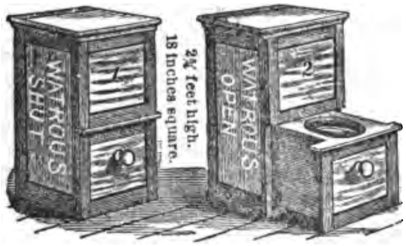

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CONDUCTED BY E. L. YOUMANS.

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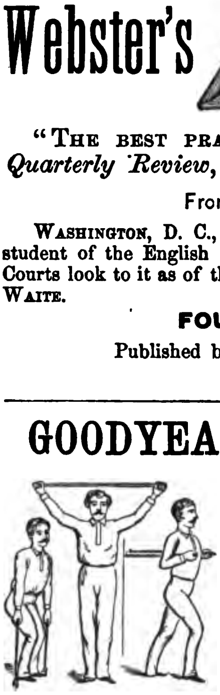

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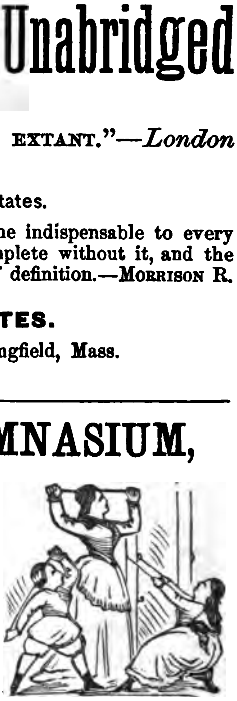

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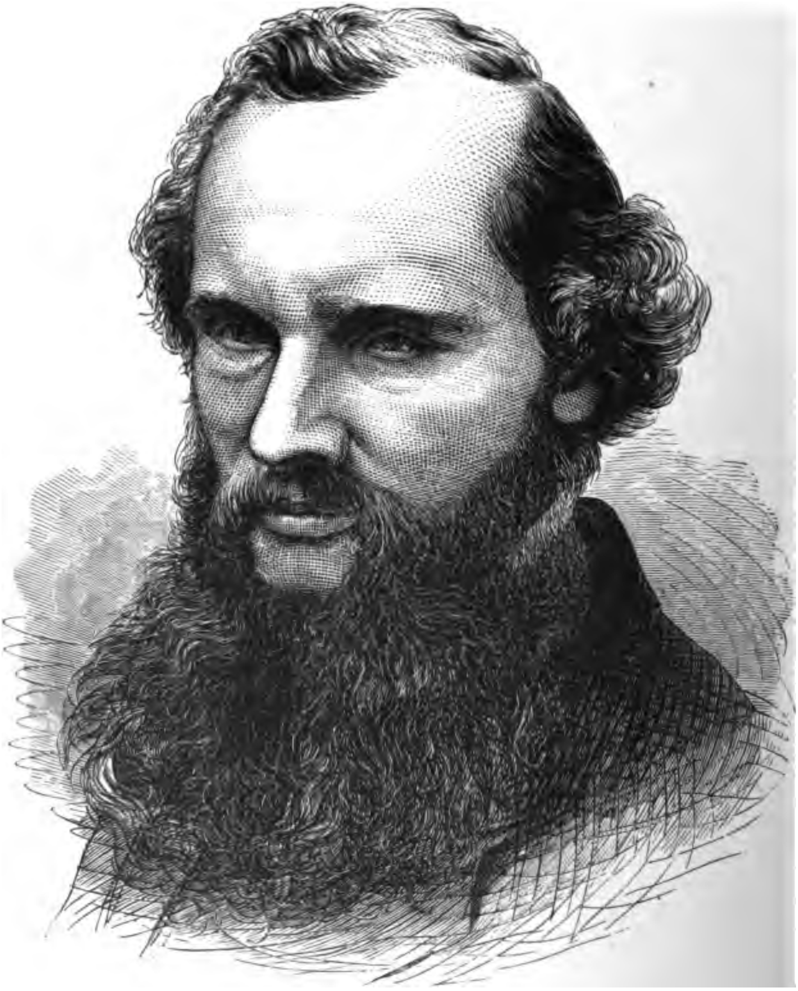

SIR WILLIAM THOMSON.

THE
POPULAR SCIENCE
MONTHLY.

JANUARY, 1877

THE EARLIER FORMS OF LIFE.

By Professor C. H. HITCHCOCK,
STATE GEOLOGIST OF NEW HAMPSHIRE.

THE surmises and discoveries of the past twenty years have established the fact of the existence of life throughout the entire series of stratified rocks known to geologists, both sedimentary and metamorphic. When Principal Dawson published his description of the Eozoön in the Laurentian foundations, he was led to suggest the adoption of the term *Eozoic* in place of *Azoic* for all the ages older than Paleozoic, since, if life existed in the oldest formation, it must have continued to flourish in the following æons, even though evidences of its presence had not then been accumulated. Time has ap proved of this sagacious anticipation, and we can now maintain with serene confidence that the four great Eozoic periods—Laurentian, Labrador, Atlantic or Montalban, and Huronian—were all enlivened by the existence of both vegetable and animal life. And Eozoic life had its peculiar characteristics just as much as the Silurian or Carboniferous.

This life has appeared in consonance with the general principles of evolution as announced by our most learned sages. The earliest organic forms were the simplest in their structural relations; and they flourished through untold ages. The world was no longer young when the organic scheme permitted the growth of Cambrian trilobites and mollusca. More than half of geological time had passed away during the reign of protozoans and fungi. This suggests the enunciation of a general principle, in perfect agreement with the doctrines of evolution: the simpler the predominating forms of life the longer the period. In the beginning of Nature's operations, time was the element of which lavish use was made. It has grown more valuable as the ages have passed on, and the perfected type of organic development in our period grudges the loss of a single moment of it.

The evidences of the earlier forms of life naturally divide themselves into two groups, or those relating to plants and animals, which we will consider in their natural order:

Evidences of Plant-Life.—An interesting evidence of the existence of vegetation in Eozoic times is derived from the presence of iron-ores, an argument first set forth by Sterry Hunt. The ores are first formed in the hydrated condition, and then lose their water by metamorphic agencies, becoming specular and magnetic, or the state in which the Laurentian irons are now known. Ores of iron are conceived to have been formed under similar conditions in all ages. At the present day they accumulate in swamps and low grounds in the condition of the hydrated peroxide (ferric), or bog-ore, oftentimes in company with manganese. The presence of organic vegetable matter is requisite in order to extract the iron from the rock or soil and effect its deposition. The metal present in slight amount in the soil is the insoluble ferric oxide, or the familiar condition of iron-rust. Water charged with soluble vegetable infusions, like that in swamps too full of the disagreeable extract of leaves, etc., to be palatable, has the power of dissolving ferric oxide. The process consists in the removal of a part of the oxygen by the vegetable compound, or deoxidation, when the compound becomes changed into the readily-soluble ferreous oxide. But this is not a stable compound in the presence of our atmosphere. The rejected oxygen is brought back again, and in its recombination takes water with it, producing the hydrated ferric oxide, which, being insoluble, is precipitated, and covers the ground on the bottom of the pool. On visiting almost any swamp at the present day, this reddish-brown coating of hydrated iron-rust may be seen abundantly. Where streams of water cause the swampy water to flow to lower regions, the iron compound is also conveyed in suspension, and in the course of a few years a thick deposit of ore is accumulated. Our New England ancestors used these beds for the manufacture of their pig-iron in localities where only the name now exists for the village, such as the Tamworth or Gilmanton Iron-Works. All tradition of the manufacture there has disappeared. The Katahdin Company, in Maine, however, and some others, still derive their ore-supplies from this bog-compound.

Our theory supposes that the principal iron-ores in every age of the world had their origin in this way. There is no other agent save this organic extract which produces iron-ore on a large scale at the present day; hence it is rational to explain the origin of ancient ferruginous beds in the same way. If we examine the formations in order, we find the very ores themselves obviously thus accumulated: 1. There are the early Tertiary limonite beds of Western New England, New Jersey, and Pennsylvania, still scarcely removed from the bog form, with the accompanying clays. 2. There are the older Carboniferous nodules and the celebrated Clinton hematites, differing from the limonites only by the absence of water. 3. The specular

Huronian ores of Lake Superior have the same composition as the Silurian deposits. Lastly, the Laurentian magnetites constitute the other extreme of the ferruginous series. Both the water and a part of the oxygen have disappeared, leaving a compound richer in metal, and therefore more highly prized by the smelter. The application of a gentle, continuous heat is adequate to explain the change of the limonites into hematites and magnetites.

The process of change may be seen in the manufacture of common bricks, or the purification of quartz for the production of glass. The blue clay becomes red when burned, because it parts with its water of composition; and likewise the small percentage of hematite in the quartz becomes magnetic on the application of heat, and, after pulverization, has the iron removed by magnets, so that the silica-flour may be perfectly pure, and not impart a green tint to the glass. It is not maintained that the native limonites have been converted into magnetites in precisely the way in which the same results have been accomplished artificially; but the manipulation of the manufactured products shows that the metamorphosis is a feasible process, and by no means of difficult accomplishment in Nature.

In a review of a report by the author, in which this theory of iron-ore origin is elucidated, Prof. Dana objects[1] to its value, because "carbonic acid, which does now some of the work of iron-transportation, may have done far more then," on account of its presence in the atmosphere in great abundance. No doubt exists as to the assistance afforded by carbonic acid in this work, but this fact only confirms the truth of our argument, since no chemist will allow that carbonic acid can remove the iron-rust from the soil without the help of some deoxidating agent, such as vegetation. The chemical change for which we require the presence of vegetation is the same, whether carbonic acid be involved or not. Indeed, an excellent authority for the form in which this change is effected is the professor's own treatise on mineralogy,[2] where he says, "The iron is transported in solution as a *protoxide* carbonate in carbonated waters, a sulphate, or as a salt of an organic acid." Each of these methods requires the presence of a deoxidating agent like vegetation; and nothing better has yet been suggested. The iron-ores produced by volcanic ejections are of very limited amount, and mingled with too much dead rock to be capable of utilization. Nor does the suggestion of the decomposition of pyrites by atmospheric agents to form limonite necessitate the origin of all iron-ores in that way.

Accepting the validity of the argument, it follows that vegetation must have been extremely abundant in the Laurentian and Huronian ages on account of the presence in them of enormous deposits of iron-ores, as on Lake Superior, in the Adirondacks, Missouri, etc. Some of the beds are hundreds of feet in thickness.

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[1] *American Journal of Science*, iii., vol. ix., p. 223.

[2] Fifth edition, p. 173.

The presence of graphite, or plumbago, in the Eozoic rocks is by many regarded as a still stronger argument for the former existence of vegetation. As graphite is nearly pure carbon, it is easy to believe that it has accumulated from the remains of plants. Greater changes have been effected in its mass through metamorphism than in the alterations of the ore-beds. No traces of vegetable structure have yet been detected in graphite, so that no evidence as to the nature of the earliest plants can be afforded from morphology.

NATURE OF THE EOZOIC FLORA.—What species of vegetation can we imagine to have existed in these early periods? Possibly we may derive a hint as to its nature from the general course of plant-development in later ages, and assume that there has been a correspondence between the order in which the different classes have appeared and their successive stages of complexity of structure. The simpler forms should appear first; or, reversing the statement, if we find a succession of all the higher forms of growth in later times, it is reasonable to expect in the still earlier periods larger developments of the inferior cryptogams, such as now play a comparatively insignificant part in the economy of Nature. Their easy decomposition would prevent the preservation of their specific shapes as fossils.

To particularize, we have among the lower orders of terrestrial vegetation the lichens, by some thought to be the parent of the fungi and algæ, since they can be resolved into two different plants, a fungus parasitic upon an alga; the mushrooms, puff-balls, mildews, blight, or fungi; the hepaticæ, and mosses. Of aquatic vegetation there are the numerous protophytes, the diatoms, with their siliceous shells; the desmids, the coccoliths, with their lenticular calcareous disks; the nullipores and corallines, making calcareous incrustations; and the great family of Algæ, simple, branched, and confluent. These afford us abundant material from which we may reconstruct the Eozoic meadows, forests, and submarine carpets.

The present system of plants seems to have originated in the Cretaceous period. The older Mesozoic gives us the cycads and tree-ferns, like those of the Asiatic tropics. The Paleozoic formations furnish a unique assemblage of combined cryptogamous and phenogamic nature of types not now existing. Granting that the two divisions of the plant kingdom are of equal importance in the line of development, we find ourselves in Silurian times only half-way back to the starting-point. If the Cambrian should furnish us with representations of the mosses and lichens, we might expect in Eozoic times some of these, together with the protophytes, etc., in order to complete the systematic and orderly development of the plant kingdom in time. Furthermore, the later ages have afforded gigantic representations of the higher orders. Why, then, should not the Eozoic land have had its forests of mushrooms and arborescent lichens; its swamps of diatoms, confervæ, the charæ and desmids, and enormous aquatic growth of algæ, coccoliths, nullipores, and corallines? If we grant that the parasitic fungi could not exist for want of their proper organic food of higher organization, there are still enough forms remaining to take their place, and thus afford us a symmetrical development of all the phases of vegetable growth in the enormous periods when the simplest organic structures ruled the world.

Evidences of Animal Life.—It has been argued by high authority that the existence of carbonate and phosphate of lime suggests the presence of animal life in the Laurentian seas, because at the present day these mineral substances are principally derived from organic secretions. The graphite may also have been partly of animal derivation. There is as much carbon in the Laurentian as in the Paleozoic Carboniferous. But these indications need not be dwelt upon, since recent discoveries have brought to light the actual relics of protozoans preserved in stones of Laurentian age. These are so convincing that the discussion of probabilities derived from rocks of supposed organic origin need not be dwelt upon. The organism has the name *Eozoön Canadense*, the *dawn-animal*, inhabiting the Canadian district.

Several names are connected with the discovery of this *Eozoön* from Ontario and elsewhere. Dr. Wilson, of Perth, sent specimens of it many years since to Sir William E. Logan, Director of Canadian Geological Survey, in which Dr. Sterry Hunt found a new hydrous silicate, which he called Loganite. In 1858 J. McMullen brought specimens which reminded Logan of the *Stromatopora* of the Silurian. They were examined by various scientists, and in 1865 a composite paper upon the geology, paleontology, and mineralogy of the fossil appeared in the journal of the Geological Society of London, prepared by Messrs. Logan, Dawson, Carpenter, and Hunt. Soon after Vennor discovered other specimens in the Montalban of Tudor, Ontario; Gümbel recognized it in both the Laurentian and Huronian in Bavaria; Bicknell and Burbank discovered it in Laurentian limestones at Newbury and Chelmsford, Massachusetts; and Edwards described it from the Adirondacks in New York. Scientists have not universally accepted the genuineness of this fossil. I will endeavor to present a brief sketch of the nature of the organism before stating their objections.

This animal structure belongs to the subkingdom Protozoa, a unique and inferior group of organisms. These animals are distinguished by possessing no alimentary cavity, or, if a stomach be present, it is not bounded by any walls. The three divisions, using the classification adopted by Dawson, are: the *Rhizopods*, *Sponges*, and *Infusoria*. The first is the lowest, including all the sarcodous animals whose only external organs are pseudopodia. The rhizopods are divided into the *Reticularia* or *Foraminifera*, possessing thread-like and reticulating pseudopodia with granular matter instead of a nucleus, and with calcareous, membranous, or arenaceous skeletons; the *Radiolaria* and *Lobosa*, the first being the lowest, and embracing Eozoön. The reticularia may be still further divided into two suborders, *Perforata* and *Imperforata*, the first having calcareous skeletons penetrated with pores. This is the higher one, and holds Eozoön. Of the three families *Nummulinidæ*, *Globigerinidæ*, and *Lagundæ*, Eozoön belongs to the first and the highest in rank. It is not strictly, then, the lowest of the animal kingdom, though very near to it.

Fig. 1 shows several species of the foraminifera.

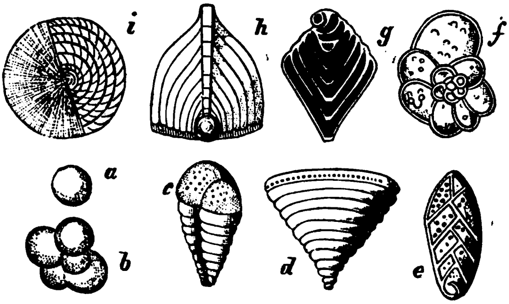

FIG. 1.—RHIZOPODS.

a, Orbulina universa; *b*, Globigerina rubra; *c*, Chrysalidina gradata; *d*, Cuneolina pavonia; *e*, Grammostomum phyllodes; *f*, Rotalia globosa; *g*, Flabellina rugosa; *h*, Frondicularia annularis; *i*, Nummulites nummularia.

The animal part of the rhizopods is a gelatinous body called sarcode, a bit of scarcely-organized protoplasm. Food is taken in through the outer wall, and is made into small pellets, which are surrounded by a digestive fluid in extemporized stomachs. Minute granules move about the interior, perhaps the substitute for a circulating fluid; and the outer wall can be moulded into the long processes called pseudopodia, used for locomotion and prehension. When these rhizopods secrete stony matter for a covering, the interior is the same structureless mass; but the shells assume characteristic forms for the different varieties. The *Orbulina* consists of a single cell with one orifice, but permeated by numerous microscopic pores, through which the protoplasmic material can ooze and form the pseudopodia. In the *Globigerina* and other genera there are several cells agglutinated together, all communicating with one another. In many species the thin cell-wall is inadequate for the wants of the structure, and an additional growth or "supplementary skeleton" is added, traversed by tubes larger, longer, and more branched, than in the first. In the ocean these minute creatures swarm in astonishing numbers, and their remains accumulate at the bottom, commingled with a paste of still more minute coccoliths and calcareous *débris* to form the ooze brought up in the sounding-lead from the telegraphed plateau. When this calcareous mixture becomes solidified it is the chalk which abounds in the Cretaceous formation of Europe, and makes up the nummulitic and orbitoidal limestones.

Fig. 2 is a close copy of a small slab of Eozoön, showing what are called the laminated, acervuline, and fragmental portions. The diagonal white line represents the course of a vein of calcite. The dark lines and marks correspond to the sarcode or animal matter of the animal, now consisting of serpentine. Calling the base of the figure the ocean-floor, there may be said to grow upon it the gelatinous sarcode or dark mass. Upon it grew first the delicate calcareous shell, penetrated by the numerous minute orifices or tubuli, larger pores, and occasionally supports of perpendicular plates. Added to this is the supplemental skeleton without the minute tubuli, but traversed by branching canals. This whole skeleton is represented by the white mass next the dark base, consisting of calcite. These two layers or laminæ constitute the essential part of the structure, and all the numerous layers above are but repetitions of them. Each lamina may cover several inches square of surface at the bottom of the ocean, and perhaps diminish in size as the organism grew upward. In the sketch the layers are seen to grow thinner toward the top, as if the vital energy became exhausted by the demands made upon it, and the supplemental skeleton first disappears. Finally, we have a mass of rounded chambers irregularly piled up near the top, constituting the "acervuline" structure. We may suppose the growth arrested at this stage, and the sending forth of reproductive germs to found new colonies in the adjacent ground.

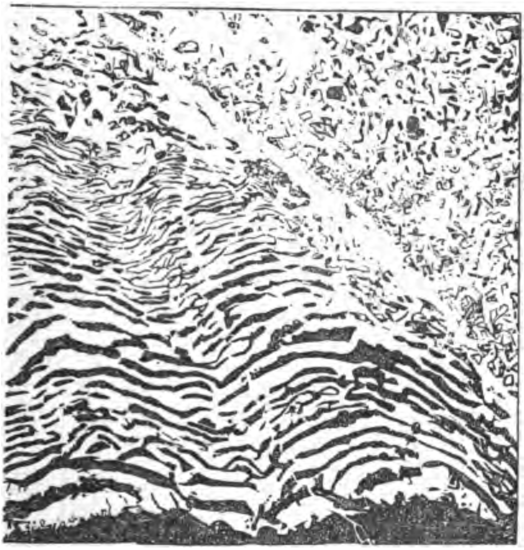

FIG. 2.—NATURE-PRINT OF EOZOÖN. (DAWSON.)

In Fig. 3 we have an enlarged restoration, after Dawson, of a portion of the Eozoön structure, which will enable us to better appreciate the several parts of the organism. The dark, granulated layers at the base and at intervals higher up constitute the chambers, and contain the sarcode or gelatinous animal matter. Immediately above and below each dark layer is the thin calcareous shell penetrated by the minute orifices or tubuli. The white spaces represent the supplementary skeletons traversed by the larger canals. At the summit the sarcode is developed into several pseudopodia or cilia, by means of which food is brought to be assimilated.

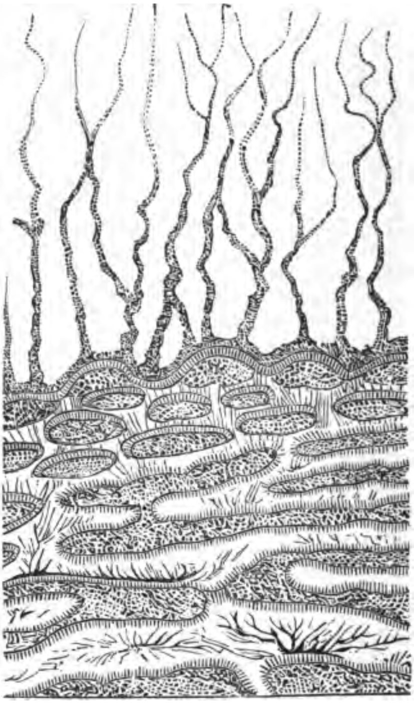

FIG. 3.—EOZOÖN RESTORED. (After Dawson.)

In Fig. 4 we have a portion of Eozoön magnified one hundred diameters, drawn by Carpenter. The upper covering (*a a*) represents the original cell-wall penetrated by the tubuli or pores in great abundance. A bit of this is still more magnified in 2, by the side of the first, seemingly consisting of an upper and lower part. The greater part of the sketch consists of the supplemental or intermediate skeleton, traversed by two kinds of canals (*b*, *c*), of much larger size and greater irregularity than the tubulation of the cell-wall.

The arrangement and composition of the mineral matter of the Eozoön is quite interesting, and the more remarkable since it has awakened hostile criticism and resulted in illustrating the presence of silicates in organisms in every age of the world. Formerly it was believed that carbonate of lime was the principal mineral found replacing organic substances, thus producing petrifactions. Now we have iron oxide, silica, clay, sand, sulphuret of iron, ores of copper, lead, etc., fluor-spar, heavy spar, phosphate of lime, all unmistakably occupying the place of decomposable organic material. And the discussions about Eozoön recall and enforce facts about the employment of silicates by Nature to preserve her structures, especially in foraminiferal forms. In New Jersey there are beds of green-sand of Cretaceous and Tertiary ages full of concretions composed of a silicate of iron and potash called *glauconite*. Owing to its value as a fertilizer, thousands of tons of it are annually employed by the farmers to enrich their lands. This silicate has replaced modern organic structures of various kinds, but noticeably corals, echinoderms, nummulites, and other rhizopods. The fine tubulation and pores of these microscopic structures have been penetrated by the silicates, so that, when the calcareous parts have been removed by acid, the insoluble glauconite residue shows us the forms of the chambers and cavities. This process of the infiltration of organisms by glauconite was known long before the discovery of Eozoön. It goes on at the present day at the bottoms of the warmer seas, as evidenced in the facts discovered by the numerous deep-sea dredgings recently undertaken in the interests of science. Dr. Hunt suggests that the mineral is developed through chemical reactions in the ooze at the sea-bottom, a combination of dissolved silica with iron put into the ferrous soluble condition by means of organic matter.

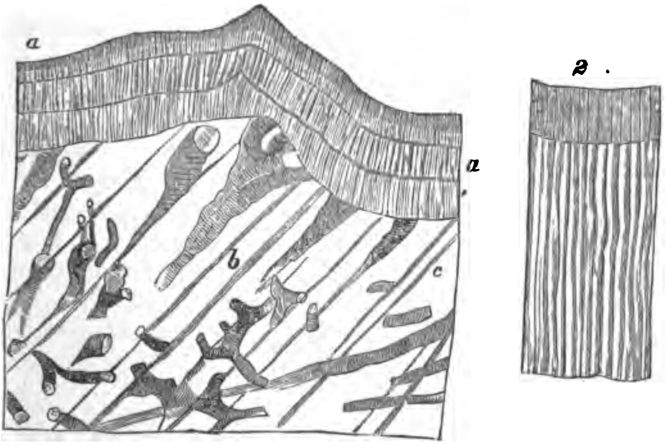

FIG. 4.—PORTION OF EOZOÖN MAGNIFIED 100 DIAMETERS. (After Carpenter.)
a a, Original cell-wall with tubulation ; *b c*, Supplementary skeleton, with canals ; 2. Portion of *a a* magnified.

Hydrous silicates act as mineralizers elsewhere than in the greensand. Crinoidal joints from the Silurian limestones of New Brunswick have been saturated by it, filling all the interstices, and small mollusks from Wales have had their interior permeated by it. There is much variation in the composition of these infiltrating silicates. Some from the *calcaire grossier*, near Paris, approach serpentine. Others carry magnesia. Those from the Lower Silurian of the Upper Mississippi Valley are like glauconite. In the Eozoön, as described above, serpentine, which is a hydrous silicate of magnesia, replaces the supposed sarcodous or animal part of the structure. It has thus corresponded to the glauconite of the present day filling the canals of the supplementary skeleton, the tubuli of the shell, and replacing the softer animal portions. Pyroxene and Loganite also replace the animal matter in the Canadian Laurentian fossils, and in the Eozoön discovered in the supposed Montalban series of Ontario carbonate of lime is the mineralizer. These last-named specimens were not described till 1867; and, as they exhibit the foraminiferal structure without the presence of any form of silicate, they completely establish the genuineness of the fossil. In Bavaria Gümbel states that chondrodite, hornblende, and scapolite, and perhaps other minerals, should be added to the list of silicates petrifying the Eozoön.

The objections that have been made to the organic character of Eozoön relate chiefly to the close resemblances between mineral and organic replacement, or between pseudomorphs and petrifactions. Other resemblances are to dendritic and concretionary structures. Inasmuch as these structures represent the higher efforts of the mineral kingdom in crystallization and the nearest approach to the inorganic world allowed by animal forms, it is not strange that the two extremes should resemble each other sufficiently to deceive practical observers. The canal system may be almost the very picture of certain dendrites. The latter, however, usually occupy a flat surface like moss-agates; whereas the former branch out in every direction, as appears in Fig. 5, projecting upward and downward, as well as sideways.

Organisms are preserved because of the more or less complete substitution of mineral for animal matter. Pieces of coal or wood that have been deposited in clay may be washed out, but the small pores and interstices will be seen to be filled with the matrix. When the burial has been in a solution capable of precipitating solid matter, the wood will be found more or less changed according to the nature of the solution and its capacity for alteration. Some specimens become nearly pure agate in consequence of the gradual substitution, particle by particle, of the organic matter by silica. Fig. 6 shows different stages of petrifaction in coniferous wood: *a* is a small fragment where the pores have been filled with silica, assuming a somewhat rhomboidal appearance, and the black parts represent the woody substance, still intact; in *b* the vegetable matter is wanting, having rotted away, and only silica remains, the rhomboidal pieces being the only remnants of the original structure. The Eozoön has not been so completely fossilized as in the example of coniferous wood. The cell-wall and supplementary skeleton still retain much of the original lime, while the animal part has been entirely replaced by serpentine or some other mineral. Subsequent pressure or desiccation has produced cracks in the mass, which have been filled with an asbestus-like mineral of silky lustre, and this has sometimes been confounded with some part of the animal by objectors.

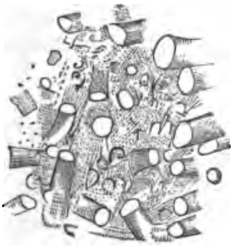

FIG. 5.—CANALS OF EOZOÖN, HIGHLY MAGNIFIED.

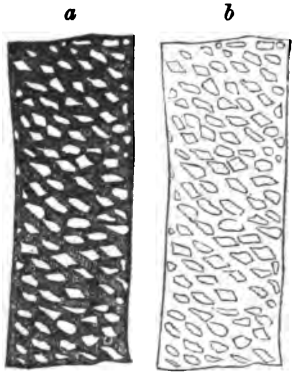

FIG. 6.—CONIFEROUS WOOD, ILLUSTRATING FOSSILIZATION.

a, Partially mineralized, the white spaces being silica, the black vegetable matter; *b*, Vegetable matter removed by decomposition, leaving outline of the forms of the original pores.

Few special subjects have been so carefully studied as the genuineness of Eozöon. The treatises of Logan, Dawson, Carpenter, and Hunt, admirably set forth every possible phase of geological position, intimate zoölogical structure and affinity, mineral character both original and derived, and the conditions of origination. The elaborate papers of the objectors, Messrs. King, Rowney, Carter, Burbank, and others, show what the weaker positions are, and have enabled the advocates to satisfactorily fortify the less defensible points of their arguments. Every new discovery seems to aid the defenders, while the philosophy of evolution is in harmony with the existence of a long Eozoöic age where the predominant life is scarcely elevated above the working of crystalline forces.

HURONIAN LIFE.—Gümbel has described a species of Eozoön from the supposed Huronian rocks of Bavaria. In this country Billings has mentioned the occurrence of an *Aspidella* and *Arenicolites* from a series of Newfoundland rocks called "Intermediate," most probably of this age. The *Aspidella* bears some resemblance to the limpet-shell or *Patella*, while it may have been some variety of crustacean. The *Arenicolites* is a petrified worm-burrow.

But the specimens of greatest interest are those brought to light the present year by Mr. George W. Hawes from the Huronian of

New Hampshire.[1] The rocks have been carefully studied stratigraphically and lithologically, so that their place in the column is well understood, and the fossil is so allied to the Eozoön as to abundantly confirm all that has been held for it by its warmest advocates.

As a matter of convenience Mr. Hawes proposes to call the group of rocks affording these organisms *greenstones*, in allusion to their color. They have not been melted like a certain class of traps once called by this name, but have been metamorphosed somewhat; they embrace most of the chloritic and talcose schists, or, technically, "all basic metamorphic rocks whose predominant coloring ingredient is either hornblende, pyroxene, or chlorite." Those of special interest to us now are varieties of diorite and diabase, the first consisting mainly of hornblende and feldspar, the second adding labradorite to the constituents of the first-named rock. These rocks by many authors are regarded as of igneous origin.

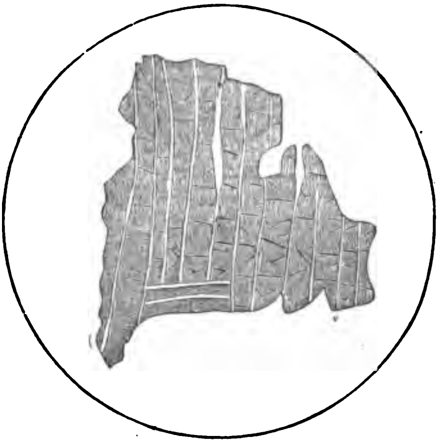

FIG. 7.—PROTOZOAN FOSSIL, PROBABLY STROMATOPORA, FROM CONNECTICUT LAKE, N. H.

The method of examination employed in determining the composition of these greenstones is of some interest. A bit of the specimen is carefully ground to the thinnest dimensions possible, so that it can be examined optically under the microscope. With common and polarized light it is possible to understand the nature of the minutest minerals present, as well as the cavities contained in them. The study of rocks in this way has been prosecuted so energetically of late, that it is common to speak of the sub-sciences micro-lithology, micropetrology, etc., and the appearances of every mineral are now well understood by those skilled in observation, so that the conclusions are often more reliable than those obtained by ultimate chemical analysis. Mr. Hawes combines in his studies the use of the microscope and chemical analysis, so that whatever cannot be determined in the one will be ascertained by the other method.

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[1] *American Journal of Science*, iii., vol. xii., p. 134.

He was accordingly gratified to recognize in one of his rock-sections the fragment of a rhizopod. The structure has some resemblance to the acaleph *Chætetes*, but on account of the minuteness of the layers it should be classed with the rhizopods, reminding one very much of the *Stromatopora*. Figs. 7 and 8 illustrate these organisms magnified thirty-five diameters, thus making the breadth of the cells only $\frac{1}{280}$ of an inch. The smaller figure is probably a section of the same rhizopod, cut in a different direction. The rock holding these fossiliferous bits is diabase, a variety common between Connecticut Lake and Bellows Falls, both in New Hampshire and Vermont.

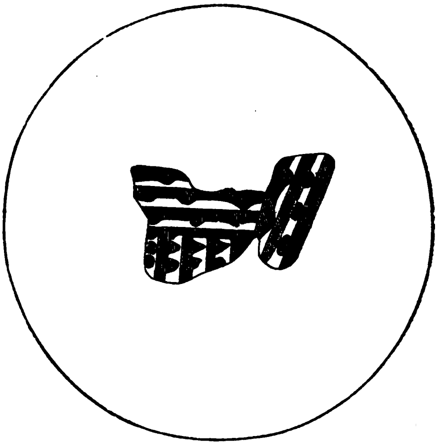

Fig. 8.—Protozoan Fossil, from Hanover, N. H.

Since the naming of *Stromatopora* by Goldfuss fifty years since, naturalists have separated the acaleph structures from the true corals, but this genus is generally regarded as different from either of them. Prof. Hall described it as a polyp-coral in his "Paleontology of New York," but would not so regard it now. The most common form of it, as figured by him, is herewith presented (Fig. 9), from the Niagara limestone of Lockport, occurring in masses one or two feet in diameter. It is a protozoan coral, assisting in the work of reef-building, however, as much as the polyp-structures. By way of comparison we add a figure of a bryozoan mollusk (*Lichenalia concentrica*), from the same formation and locality with the *Stromatopora* (Fig. 10). The relations of our new specimens are rather with the first of these forms, and will probably be described hereafter as species of *Stromatopora*.

It is an interesting fact that these "layer corals" have impressed the minds of all students of the Eozoön by their resemblances to the dawn-animal. Logan speaks of it in his first remarks upon them, referring more particularly to their weathered outcrops and somewhat concentric structure; while Dawson sees much in their internal organization suggestive of a fitness for foraminiferal requirement. The layer seems better arranged for sheltering a gelatinous body, throwing out pseudopodia reaching after food, than for accommodating the sponge animals, subsisting through the passage of currents of water. The canal system, with the supplemental skeleton, is wanting in this genus, but appears in the allied forms of the Devonian.

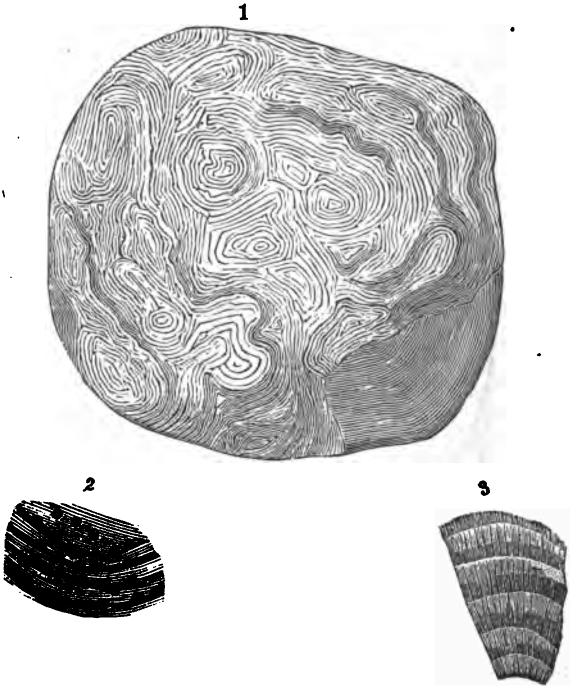

Fig. 9.—Stromatopora Concentrica. (Goldf.)

1. Surface of a small hemispheric mass, showing the edges of the thin laminæ unequally weathered, natural size.
2. Magnified portion, showing weathered edges of successive laminæ, which are indented by pores.
3. More highly-magnified portion of the specimen, showing the walls and tubulation.

A very important feature of the greenstone fossils is their mineral composition. They are composed of silicates, very probably of feldspar. Mr. Hawes has not been able yet to satisfy himself fully as to the nature of the silicate, because of the smallness of the particles obtained. A drop of acid placed upon one of the specimens exhibited a slight effervescence, indicating the traces of carbonate of lime—perhaps part of the original foraminifer before its fracture and dispersion in the mud. He suggests that the presence of these lime-structures afforded the material for the manufacture of so much labradorite in the diabases containing the fossils.

I cannot forbear alluding to the interesting confirmation of the genuineness of Eozoön afforded by the discovery of these Huronian fossils in New Hampshire: 1. Eozoön sprung upon us with affinities rather remote from existing forms, but the *Stromatopora* has been known for fifty years as a veritable organism. 2. The latter has the same silicated condition with the former ; hence we cannot set aside Eozoön merely because the supposed animal parts have been infiltrated by a silicate. A well-known organism is proved to be silicated; hence all presumption against the existence of the same mineral condition in a related animal is removed. 3. *Stromatopora* is zoölogically allied to Eozoön. 4. It appears in a subsequent period, showing a natural order of development. 5. Stratigraphical and petrographical studies prove the greenstones to satisfactorily belong to the true Huronian formation, and thus make the sequence of life free from ambiguity.

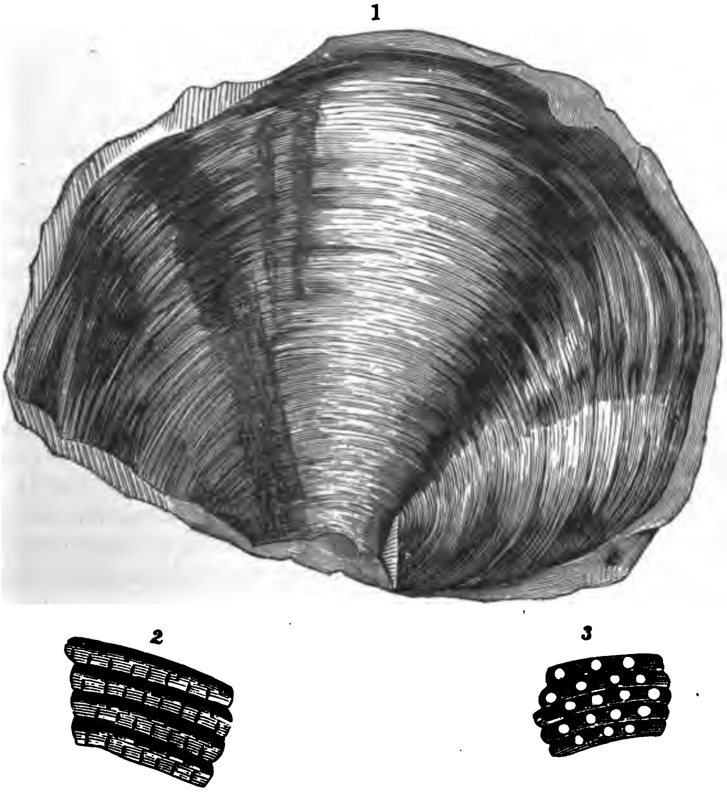

Fig. 10.—Lichenalia Concentrica. (Hall.)

1. A nearly perfect frond.
2, 3. Enlargements of the non-celluliferous side, showing the form and arrangement of the stigmata.

Eozoic Geography.—Such vast periods are necessarily involved in those early stages of the earth's growth, that we cannot portray

Eozoic scenery as a whole; while an artist would find material for only one sketch. At the first we must conceive of an earth with a larger diameter than is now accepted as the standard for the metric system of measures; of a shallow ocean covering the greater portion of the surface, interspersed with numerous islands, scattered everywhere without any method of arrangement that we understand. In the areas marked as Eozoic upon our maps, accumulations of strata were going on, of enormous thickness. We cannot recognize now the original land which supported the primeval vegetation, but can conjecture the boundaries of the contiguous oceans. In the latter part of the period the areas of deposition occupied basins situated within the limits of the earlier-formed rocks, being usually the deeper portions of the original oceans. Ridges between the water-basins resulted from the slow elevation of the land, the nuclei of great mountain-ranges, and there were ejections of melted matter, with marvelous alterations of sediments deep down beneath the surface.

Respecting the age as a whole, we may say that the waters were probably somewhat thermal, still simmering from the proximity of the heated interior; the air was thick and moist, partly composed of carbonic-acid gas; the sky was filled with dense clouds, marking the transition of day and night by periods of total darkness and seasons of feeble illumination, not permitting sunshine to cheer the vegetation. The life was characterized by its lowness of grade; the terrestrial plants hardly suitable for the food of air-breathing animals; the marine largely of the lime-secreting varieties and unicellular diatoms. The animals colonized the bottoms of the oceans, building up enormous reefs, but invisible to sight, if any one could have been permitted to look upon the infant world.

THEORIES OF PRIMITIVE MARRIAGE.[1]

By HERBERT SPENCER.

IN his ingenious and interesting work on "Primitive Marriage," the words "exogamy" and "endogamy" are used by Mr. McLennan to distinguish the two practices of taking to wife women belonging to other tribes, and taking to wife women belonging to the same tribe. As explained in his preface, his attention was drawn to these diverse customs by an inquiry into "the meaning and origin of the form of capture in marriage ceremonies;" an inquiry which led him to a general theory of early sexual relations. The following outline of his theory I disentangle, as well as I can, from statements that are not altogether consistent.

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[1] From advance-sheets of Spencer's "Principles of Sociology," Part "The Domestic Relations," chap. iv., "Exogamy and Endogamy."

Scarcity of food led groups of primitive men to destroy female infants; because, "as braves and hunters were required and valued, it would be the interest of every horde to rear, when possible, its healthy male children. It would be less its interest to rear females, as they would be less capable of self-support, and of contributing, by their exertions, to the common good" (p. 165).

Mr. McLennan next alleges that "the practice in early times of female infanticide," "rendering women scarce, led at once to polyandry within the tribe, and the capturing of women from without" (p. 138).

Joined with a restatement of the causes we come upon an inferred result, as follows: "The scarcity of women within the group led to a practice of stealing the women of other groups, and in time it came to be considered improper, because it was unusual, for a man to marry a woman of his own group" (p. 289). Or, as he says on p. 140, "usage, induced by necessity, would in time establish a prejudice among the tribes observing it (exogamy)—a prejudice, strong as a principle of religion, as every prejudice relating to marriage is apt to be—against marrying women of their own stock."

To this habitual stealing of wives, and restealing of them, as among the Australians (p. 76), he ascribes that doubtful paternity which led to the recognition of kinship through females only. Though elsewhere admitting a more general cause for this primitive form of kinship (p. 159), he regards wife-stealing as its most certain cause, saying that "it must have prevailed wherever exogamy prevailed—exogamy and the consequent practice of capturing wives. Certainty as to fathers is impossible where mothers are stolen from their first lords, and liable to be restolen before the birth of children" (p. 226).

Assuming the tribes which thus grew into the practice of wife-stealing to have been originally homogeneous in blood, or at least to have supposed themselves so, Mr. McLennan argues that the introduction of wives who were foreigners in blood, joined with the rise of the first definite conception of relationship (that between mother and child) and consequent system of kinship exclusively in the female line, led to recognized heterogeneity within the tribe: there came to exist, within the tribe, children regarded as belonging by blood to the tribes of their mothers. Hence arose another form of exogamy. The primitive requirement that a wife should be stolen from another tribe, naturally became confounded with the requirement that a wife should be of the blood of another tribe; and hence girls born within the tribe, from mothers belonging to other tribes, became eligible as wives. The original exogamy, carried out only by robbing other tribes of their women, gave place, in part, or wholly, to the modified exogamy carried out by marrying, from within the tribe, women bearing family names which implied that they were foreign in blood.

In tracing the development of higher forms of the domestic relations, Mr. McLennan postulates, as we have seen, that the scarcity of women "led at once to polyandry within the tribe, and the capturing of women from without." Describing and illustrating the different forms of polyandry, ending in that highest form in which the husbands are brothers, he points out that at this stage there arose recognition not only of descent in the female line, but also of descent in the male line; since the father's blood was known, if not the father.

Then through gradually-established priority of the elder brother, as being the first of the group to marry, and the first likely to have children, it became an accepted fiction that all the children were his: "the elder brother was a sort of *paterfamilias;*" and "the idea of fatherhood" thus caused was a step toward kinship through males, and "a step away from kinship through females" (pp. 243, 244).

Pointing out that among some polyandrous peoples, as the Kandians, the chiefs have become monogamists, Mr. McLennan argues (p. 245) that their example would be followed, and "thus would arise a practice of monogamy or of polygamy." And he thence traces the genesis of the patriarchal form, the system of agnation, the institution of caste.

Though this outline of Mr. McLennan's theory is expressed, wherever regard for brevity permits, in his own words, yet possibly he may take exception to it, for, as already hinted, there are incongruities in his statements, and the order in which they are placed is involved. That many of the phenomena he describes exist, is beyond question. It is undeniable that the stealing of women, still habitual with sundry low races, was practised in the past by races now higher; and that the form of capture in marriage ceremonies prevails in societies where no real capture occurs at present. It is undeniable that kinship through females is, among various primitive peoples, the only kinship avowedly recognized; and that it leads to the descent of name, rank, and property, in the female line. It is undeniable that in many places where wife-stealing is, or has been, the practice, marriage is forbidden between those of the same family name, who are assumed to be of the same stock. But while admitting much of the evidence, and while accepting some of the inferences, we shall find reason for doubting Mr. McLennan's theory taken as a whole. Let us consider, first, the minor objections.

Sundry facts inconsistent with his conclusion, though referred to by Mr. McLennan, he passes over as of no weight. He thinks there is warrant for the belief that exogamy and wife-capture have "been practised at a certain stage among every race of mankind" (p. 138): this stage being the one now exemplified by sundry low races. Nevertheless, he admits that "the separate endogamous tribes are nearly as numerous, and they are in some respects as rude, as the separate exogamous tribes" (p. 145). Now, if, as he believes, exogamy and wife-stealing have "been practised at a certain stage among every race of mankind"—that stage being the primitive one—and if, as he seeks to prove, endogamy is a form reached through a long series of social developments, it is difficult to understand how the endogamous tribes can be as rude as the exogamous ones.

Again, he names the fact that "in some districts—as in the hills on the northeastern frontier of India, in the Caucasus, and the hill-ranges of Syria—we find a variety of tribes, proved, by physical characteristics and the affinities of language, of one and the same original stock, yet in this particular differing *toto cœlo* from one another—some forbidding marriage within the tribe, and some prescribing marriage without it" (pp. 147, 148): a fact by no means congruous with his hypothesis.

Should Mr. McLennan reply that on pp. 47, 48, he has recognized the possibility, or probability, that there were tribes primordially endogamous—should he say that on pp. 144, 145, will be found the admission that, perhaps, exogamy and endogamy "may be equally archaic," the rejoinder is that, besides being inconsistent with his belief that exogamy has "been practised at a certain stage among every race of mankind," this possibility is one which he practically rejects. On pp. 148–150, he sketches out a series of changes by which exogamous tribes may eventually become endogamous; and in subsequent sections on the "Growth of Agnation," and "The Rise of Endogamy," he tacitly asserts that endogamy has thus developed: if not without exception, still, generally. Indeed, the title of one of his chapters—"The Decay of Exogamy in Advancing Communities"—clearly implies the belief that exogamy was general, if not universal, with the uncivilized; and that endogamy grew up along with civilization. Thus the incongruity between the propositions quoted in the last paragraph cannot be escaped.

Sundry other of Mr. McLennan's statements and inferences conflict with one another. Assuming that, in the earliest state, tribes were stock-groups "organized on the principle of exogamy," he speaks of them as having "the primitive instinct of the race against marriage between members of the same stock" (p. 118). Yet, as we have seen above, he elsewhere speaks of wife-capture as caused by scarcity of women within the tribe; and attributes to this "usage, induced by necessity," the prejudice against "marrying women of their own stock." Moreover, if, as he says (and I believe rightly says) on p. 145, "men must originally have been free of any prejudice against marriage between relations," it seems inconsistent to allege that there was a "primitive instinct" "against marriage between members of the same stock."

Again, while in some places the establishment of the exogamous prejudice is ascribed to the practice of wife-stealing (pp. 53, 54, and 136), it is elsewhere made the antecedent of wife-stealing: interdict against marriage within the tribe was primordial. Now, if this last is Mr. McLennan's view, I agree with Sir J. Lubbock in thinking that it is untenable. It cannot be assumed that in these earliest groups of men, with which Mr. McLennan commences, there were any established rules of marriage. Unions of the sexes must have preceded all social laws. The rise of a social law implies a certain preceding continuity of social existence; and this preceding continuity of social existence implies the reproduction of successive generations. Hence reproduction, entirely unregulated by interdicts, must be taken as initial.

Assuming, however, that of his two views Mr. McLennan will abide by the more tenable one, that wife-stealing led to exogamy, let us ask how far he is justified in alleging that female infanticide, and consequent scarcity of women, led to wife-stealing. At first sight it appears undeniable that destruction of infant girls, if frequent, must have been accompanied by a deficiency of adult females; and it seems strange to call in question the legitimacy of this inference. But Mr. McLennan has overlooked a concomitant. Tribes in a state of chronic hostility are constantly losing their adult males, and the male mortality so caused is usually considerable. Hence the killing many female infants does not necessitate paucity of women: it may merely prevent excess. Excess must, indeed, be inevitable if, equal numbers of males and females being reared, some of the males are from time to time slain. The assumption from which Mr. McLennan's argument sets out is, therefore, inadmissible.

How inadmissible it is, becomes conspicuous on finding that, where wife-stealing is now practised, it is commonly associated with polygyny. The Fuegians, named by Mr. McLennan among wife-stealing peoples, are polygynists. According to Dove, the Tasmanians were polygynists, and Lloyd says that polygyny was universal among them; yet the Tasmanians were wife-stealers. The Australians furnish Mr. McLennan with a typical instance of wife-stealing and exogamy; and though Mr. Oldfield alleges scarcity of women among them, yet other testimony is quite at variance with his. Mitchell says: "Most of the men appeared to possess two [females], the pair in general consisting of a fat plump gin, and one much younger;" and, according to the Frenchman Peltier, named in the last chapter as having lived seventeen years with the Macadama tribe in Queensland, the women were "more numerous than the men, every man having from two to five women in his suite." In North America the Dakotas are at once wife-stealers and polygynists, Burton tells us. In South America the Brazilians similarly unite these two traits; and among the Caribs they are especially associated. Writing of polygyny as practised on the Orinoco, Humboldt says: "It is most considerable among the Caribs, and all the nations that have preserved the custom of carrying off young girls from the neighboring tribes." How, then, can wife-stealing be ascribed to scarcity of women?

A converse incongruity also militates against Mr. McLennan's theory. His position is that female infanticide, "rendering women scarce, led at once to polyandry within the tribe, and the capturing of women from without." But polyandry does not, so far as I see, distinguish wife-stealing tribes. We do not find it among the above-named Tasmanians, Australians, Dakotas, Brazilians; and although it is said to occur among the Fuegians, and characterizes some of the Caribs, it is much less marked than their polygyny. Contrariwise, though it is not a trait of peoples who rob one another of their women, it is a trait of certain rude peoples who are habitually peaceful. There is polyandry among the Esquimaux, who do not even know what war is; there is polyandry among the Todas, who in no way aggress upon their neighbors

Other minor difficulties might be dwelt upon. There is the fact that in many cases exogamy and endogamy coexist, as among the Comanches, the New-Zealanders, the Lepchas, the Californians. There is the fact that in sundry cases polygyny and polyandry coexist, as among the Fuegians, the Caribs, the Esquimaux, the Warans, the Hottentots, the ancient Britons. There is the fact that there are some exogamous tribes who have not the form of capture in marriage, as the Iroquois and the Chippewas. But, not dwelling on these, I turn to certain cardinal difficulties, obvious *a priori*, which appear to me insuperable.

Setting out with primitive homogeneous groups, Mr. McLennan contends that the scarcity of women caused by destruction of female infants compelled wife-stealing; and he thinks that this happened "at a certain stage among every race of mankind" (p. 138). The implication is, therefore, that a number of adjacent tribes, usually belonging to the same variety of man in the same stage of progress, were simultaneously thus led to rob one another. But immediately we think of wife-stealing as a practice not of one tribe only, but of many tribes forming a cluster, there presents itself the question, How was the scarcity of women thus remedied? If each tribe had fewer women than men, how could the tribes get wived by robbing one another? The scarcity remained the same: what one tribe got another lost. Bearing in mind the low fertility and great infant mortality among savages, if there is a chronic deficiency of women and the tribes rob one another equally, the result must be diminished population in all the tribes. If some, robbing others in excess, get enough wives, and leave certain of the rest with very few, these must tend toward extinction. And if the surviving tribes carry on the process, there appears no limit until the strongest tribe, continuing to supply itself with women from the less strong, finally alone survives and has no tribes to rob.

Should it be replied that female infanticide is, on the average of cases, not carried so far as to make the number of wives insufficient to maintain the aggregate population—should it be said that only exceptional tribes rear so few women as not to have mothers enough to produce the next generation—then we are met by a still greater difficulty. If in each of the exogamous tribes forming the supposed cluster the men are forbidden to marry women of their own tribe, and must steal women from other tribes, the implication is that each tribe knowingly rears wives for neighboring tribes, but not for itself. Though each tribe kills many of its female infants that it may not be at the cost of rearing them for its own benefit, yet it deliberately rears the remainder for the benefit of its enemies. Surely this is an inadmissible supposition. In proportion as the interdict against marrying women within the tribe is peremptory, the preservation of girls will be useless—worse than useless, indeed, since adjacent hostile tribes, to whom they must go as wives, will be thereby strengthened. And as all the tribes, living under like interdicts, will have like motives, they will all of them cease to rear female infants.

Manifestly, then, exogamy in its original form can never have been anything like absolute among the tribes forming a cluster, but can have been the law among some of them only.

In his concluding chapter Mr. McLennan says that, "on the whole, the account which we have given of the origin of exogamy appears the only one which will bear examination" (p. 289). It seems to me, however, that setting out with the postulate laid down by him, that primitive groups of men are habitually hostile, we may, on asking what are the concomitants of war, be led to a different theory, open to none of the objections above raised.

In all times and places, among savage and civilized, victory is followed by pillage. Whatever portable things of worth the conquerors find, they take. The enemies of the Fuegians plunder them of their dogs and arms; pastoral tribes in Africa have their cattle driven away by conquering marauders; and peoples more advanced are robbed of their money, ornaments, and all valuable things that are not too heavy. The taking of women is manifestly but a part of this process of spoiling the vanquished. Women are prized as wives, as concubines, as drudges; and, the men having been killed, the women are carried off along with the other movables. Everywhere among the uncivilized we find this. Turner tells us that "in Samoa, in dividing the spoil of a conquered people, the women were not killed, but taken as wives." We learn from Mitchell that in Australia, "on some whites telling a native that they had shot a man of another tribe, his only remark was: 'Stupid white fellows! why did you not bring away the gins?'" And P. Martyr says that among the cannibal Caribs in his day "to eat women was considered unlawful. . . . Those who were captured young were kept for breeding, as we keep fowl, etc." Early legends of the semi-civilized show us the same thing; as when in the "Iliad" we read that the Greeks plundered "the sacred city of Eëtion," and that part of the spoils "they divided among themselves" were the women. And there need no examples to recall the fact that in later and more civilized times successes in battle have been followed by transactions allied in character, if not the same in form. Hence it is obvious that, from the beginning down to comparatively late stages, women-stealing has been an *incident* of successful war.

Observe, next, that the spoils of conquest, some of them prized for themselves, are some of them prized as trophies. Proofs of prowess are above all things treasured by the savage. He brings back his enemy's scalp, like the North American Indian. He dries and preserves his enemy's head, like the New-Zealander. He fringes his robe with locks of hair cut from his slain foe. Among other signs of success in battle is return with a woman of the vanquished tribe. Beyond her intrinsic value she has an extrinsic value. Like a native wife, she serves as a slave; but, unlike a native wife, she serves also as a trophy. As, then, among savages, warriors are the honored members of the tribe—as among warriors the most honored are those whose bravery is best shown by achievements—the possession of a wife taken in war becomes a badge of social distinction. Hence members of the tribe thus married to foreign women are held to be more honorably married than those married to native women. What must result?

In a tribe not habitually at war, or not habitually successful in war, no decided effect is likely to be produced on the marriage customs. If the great majority of the men have native wives, the presence of a few whose superiority is shown by having foreign wives will fail to change the practice of taking native wives: the majority will keep one another in countenance. But if the tribe, becoming more successful in war, robs adjacent tribes of their women more frequently, there will grow up the idea that the now-considerable class having foreign wives form the honorable class, and that those who have not proved their bravery by bringing back these living trophies are dishonorable: non-possession of a foreign wife will come to be regarded as a proof of cowardice. An increasing ambition to get foreign wives will therefore arise; and as the number of those who are without them decreases, the brand of disgrace attaching to them will grow more decided; until, in the most warlike tribes, it becomes an imperative requirement that a wife shall be obtained from another tribe—if not in open war, then by private abduction.

A few facts showing that by savages proofs of courage are often required as qualifications for marriage, will carry home this conclusion. Herndon tells us that among the Mahués a man cannot take a wife until he has submitted to severe torture. Bates, speaking of the Passés on the Upper Amazons, says that formerly "the young men earned their brides by valiant deeds in war." Before he is allowed to marry, a young Dyak must prove his bravery by bringing back the head of an enemy. Bancroft quotes Colonel Cremony as saying that when the Apache warriors return unsuccessful, "the women turn away from them with assured indifference and contempt. They are upbraided as cowards, or for want of skill and tact, and are told that such men should not have wives." That, among other results of sentiments thus exemplified, abduction of women will be one, is obvious; for a man who, denied a wife till he has proved his courage, steals one, satisfies his want and achieves reputation at the same time. If, as we see, the test of deserving a wife is in some cases obtainment of a trophy, what more natural than that the trophy should often be the stolen wife herself? What more natural than that where many warriors of the tribe are distinguished by stolen wives, the stealing of a wife should become the required proof of fitness to have one? Hence would follow a peremptory law of exogamy.

In so far as it implies that usage grows into law, this interpretation agrees with that of Mr. McLennan. It does not, however, like his, assume either that this usage originated in a primordial instinct, or that it resulted from scarcity of women caused by infanticide. Moreover, unlike Mr. McLennan's, the explanation so reached is consistent with the fact that exogamy and endogamy in many cases exist; and with the fact that exogamy often coexists with polygyny. Further, it does not involve us in the difficulty raised by supposing a peremptory law of exogamy to be obeyed throughout a cluster of tribes.

But can the great prevalence of the form of capture in marriage ceremonies be thus accounted for? Mr. McLennan believes that, wherever this form is now found, complete exogamy once prevailed. Examination will, I think, show that the implication is not necessary. There are several ways in which the form of capture naturally arises; or rather, let us say, it has several conspiring causes.

If, as we have seen, there still exist rude tribes in which men fight for possession of women, the taking possession of a woman naturally comes as a sequence to an act of capture. That monopoly which constitutes her a wife in the only sense known by the primitive man is a result of successful violence. Thus the form may originate from actual capture within the tribe instead of originating from actual capture without it.

Beyond that resistance to a man's seizure of a woman apt to be made by other men within the tribe, there is the resistance of the woman herself. Sir John Lubbock expresses the opinion that female coyness is not an adequate cause for the establishment of the form of capture; and it may be that, taken alone, it does not suffice to account for everything. But there are reasons for thinking it an important factor. Here are some of them. Crantz tells us concerning the Esquimaux that, when a damsel is asked in marriage, she—

> "directly falls into the greatest apparent consternation, and runs out-of-doors tearing her bunch of hair; for single women always affect the utmost bashfulness and aversion to any proposal of marriage, lest they should lose their reputation for modesty."

Like behavior is shown by Bushmen girls. When—

> "a girl has grown up to womanhood without having previously been betrothed, her lover must gain her own approbation, as well as that of the parents; and on this occasion his attentions are received with an affectation of great alarm and disinclination on her part, and with some squabbling on the part of her friends."

Again, among the Sinai Arabs, says Burckhardt, a bride—

> "defends herself with stones, and often inflicts wounds on the young men, even though she does not dislike the lover; for, according to custom, the more she struggles, bites, kicks, cries, and strikes, the more she is applauded ever after by her own companions." During the procession to the husband's camp, "decency obliges her to cry and sob most bitterly."

Of the Muzos, Piedrahita narrates that after agreement with the parents was made—

> "the bridegroom came to see the bride, and staid three days caressing her, while she replied by beating him with her fists and with sticks. After these three days she got tamer, and cooked his meals."

In these cases, then, coyness, either real or affected for reputation's sake, causes resistance of the woman herself. In other cases there is joined with this the resistance of her female friends. We read of the Sumatran women that "both the bride and her female relatives make it a point of honor to prevent (or appear to prevent) the bridegroom from obtaining his bride." On the occasion of a marriage among the Araucanians, Smith tells us that "the women spring up *en masse*, and arming themselves with clubs, stones, and missiles of all kinds, rush to the defense of the distressed maiden. . . . It is a point of honor with the bride to resist and struggle, however willing she may be." And once more we learn from Grieve that when a Kamtchatkan "bridegroom obtains the liberty of seizing his bride, he seeks every opportunity of finding her alone, or in company of a few people, for during this time all the women in the village are obliged to protect her."

Here we have, I think, proof that one origin of the form of capture is feminine opposition—primarily of the woman herself, and secondarily of female friends who naturally sympathize with her. Though the manners of the inferior races do not imply much coyness, yet we cannot suppose coyness to be wholly absent. Hence that amount of it which really exists, joined with that further amount simulated for reputation's sake, will make resistance, and consequently capture, natural phenomena. Moreover, since a savage makes his wife a slave, and usually treats her brutally, she has an additional motive for resistance.

Nor does forcible opposition proceed only from the girl and her female friends: the male members of her family also are likely to be opponents. A woman is of value not only as a wife, but also as a daughter; and all through, from the lowest to the highest stages of social progress, we find a tacit or avowed claim to her services by her father. It is so even with the degraded Fuegians: an equivalent in the shape of service rendered has to be given for her by the youth, "such as helping to make a canoe." It is so with numerous more advanced savages all over the world: there is either the like giving of stipulated work, or the giving of a price. And we have evidence that it was originally so among ourselves: in an action for seduction the deprivation of a daughter's services is the injury alleged. Hence it is inferable that in the rudest states, where claims, parental or other, are but little regarded, the taking away of a daughter is likely to become the occasion of a fight. Facts support this conclusion. Of the Araucanians Smith tells us that, when there is opposition of the parents, "the neighbors are immediately summoned by blowing the horn, and chase is given." "Among the Gándors, a tribe on the southern shores of the Caspian Sea, the bridegroom must run away with his bride, although he thereby exposes himself to the vengeance of her parents, who, if they find him within three days, can lawfully put him to death." And we read concerning the Gonds that "a suitor usually carries off the girl that is refused to him by the parents." Thus we find a further natural cause for the practice of capture—a cause which must have been common before social usages were well established. Indeed, on reading that among the Mapuchés the man sometimes "lays violent hands upon the damsel, and carries her off," and that "in all such cases the usual equivalent is afterward paid to the girl's father," we may suspect that abduction, spite of parents, was the primary form; that there came next the making of compensation to escape vengeance; that this grew into the making of presents beforehand; and that so resulted eventually the system of purchase.

If, then, within a tribe there are three sources of opposition to the appropriation of a woman by a man, it does not seem that the form of capture is inexplicable unless we assume the abduction of women from other tribes.

But even supposing it to have originated in the capture of foreign women, its survival as a form of marriage would not prove exogamy to have been the law. In a tribe whose warriors had many of them wives taken from enemies, and who, as having captured their wives, were regarded as more honorably married than the rest, there would result an ambition, if not to capture a wife, still to seem to capture a wife. In every society the inferior ape the superior; and customs thus spread among classes, the ancestors of which did not observe them. The antique-looking portraits that decorate many a modern, large house, by no means demonstrate the distinguished ancestry of the owner; but may merely simulate a distinguished ancestry. The coat of arms a wealthy man bears does not necessarily imply descent from men who once had their shields and flags covered by such marks of identity. The plumes borne on a hearse do not prove that the dead occupant had forefathers who wore knightly decorations. And, similarly, it does not follow that all the members of tribes who go through the form of capturing their wives at marriage are descendants of men who in earlier days actually captured their wives. Mr. McLennan himself points out that, among sundry ancient peoples, captured wives were permitted to the military class, though not to other classes. If we suppose a society formed of a dominant military class, originally the conquerors, who practised wife-capture, and a subject class who could not practise it—and if we ask what would happen when such a society fell into more peaceful relations with adjacent like societies, and obtained wives from them no longer by force, but by purchase or other friendly arrangement—we may see that, in the first place, the form of capture would replace the actuality of capture in the marriages of this dominant class; for, as Mr. McLennan contends, conformity to ancestral usage would necessitate the simulation of capture after actual capture has ceased. And when, in the dominant class, wife-capture had thus passed into a form, it would be imitated by the subject class as being the most honorable form. Such among the inferior as had risen to superior social positions would first adopt it; and they would gradually be followed by those below them. So that, even were there none of the other probable origins named above, a surviving form of capture in any society would not necessarily show that society to have been exogamous, but would merely show that wife-capture was in early times practised by its leading men.

And now, pursuing the argument, let us see whether exogamy and endogamy are not simultaneously accounted for as correlative results of the same differentiating process. Setting out with a state in which the relations of the sexes were indefinite, variable, and determined by the passions and circumstances of the occasion, we have to explain how exogamy and endogamy became established, the one here, the other there, as consequences of surrounding conditions. The efficient conditions were the relations to other tribes, now peaceful but mostly hostile, some of them strong, and some of them weak.

Necessarily, a primitive group not commonly at war with neighboring groups must be endogamous; for the taking of women from other tribes is either a sequence of open war, or is an act of private war which brings on open war. Pure endogamy, however, resulting in this manner, is probably rare, since the hostility of tribes is almost universal. But endogamy is likely to characterize not peaceful groups alone, but also groups habitually worsted in war. An occasional abducted woman taken in reprisal will not suffice to establish in a weak tribe any precedent for wife-capture; but, contrariwise, a member of such a tribe who carries off a woman, and so provokes vengeance by the stronger tribe robbed, is likely to meet with general reprobation.[1] Hence marrying in the tribe will not only be habitual, but there will arise a prejudice, and eventually a law, against taking wives from other tribes; the needs of self-preservation will make the tribe endogamous. This interpretation harmonizes with the fact, admitted by Mr. McLennan, that the endogamous tribes are as numerous as the exogamous; and also with the fact he admits, that in sundry cases clusters of tribes allied by blood and language are some of them exogamous and some endogamous.

It is to be inferred that, among tribes not differing much from one another in strength, there will be continual aggressions and reprisals, accompanied by mutual robberies of women. No one of them will be able to supply itself with wives entirely at the expense of adjacent tribes, and hence, in each of them, there will be both native wives, and wives taken from other tribes—there will be both exogamy and endogamy. Stealing of wives will not be reprobated, because the tribes robbed are not too strong to be defied; and it will not be insisted on, because the men who have stolen wives will not be numerous enough to determine the average opinion.

If, however, in a cluster of tribes, one gains predominance by frequent successes in war—if the men in it who have stolen wives come to form the larger number—if the possession of a stolen wife becomes a mark of that bravery without which a man is not worthy of a wife—then the discreditableness of marrying within the tribe, growing into disgracefulness, will end in a peremptory requirement to get a wife from another tribe—if not in open war, then by private theft: the tribe will become exogamous. A sequence may be traced. The exogamous tribe thus arising, and growing while it causes adjacent tribes to dwindle by robbing them, will presently divide; and its sections, usurping the habitats of adjacent tribes, will carry with them the established exogamous habit. When, presently becoming hostile, these diverging sub-tribes begin to rob one another of women, there will arise conditions conducive to that internal exogamy which Mr. McLennan supposes, rightly I think, to replace external exogamy. For, unless we assume that, in a cluster of tribes, each will undertake to rear women for adjacent tribes to steal, we must conclude that the exogamous requirement will be met in a qualified manner. Wives born within the tribe, but foreign by blood, will, under pressure of the difficulty, be considered allowable, instead of actually stolen wives. And thus, indeed, that kinship in the female line, which primitive irregularity in the relations of the sexes originates, will become established, even though male parenthood is known; since this interpretation of kinship will make possible conformity to a law of *connubium* that could not otherwise be obeyed.

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[1] Since the above sentence was written, I have, by a happy coincidence, come upon a verifying fact, in the just-published "Life in the Southern Isles," by the Rev. Mr. Gill (p. 47). A man, belonging to one of the tribes in Mangaia, stole food from an adjacent tribe. This adjacent tribe avenged itself by destroying the houses, etc., of the thief's tribe. Thereupon the thief's tribe, angry because of the mischief thus brought upon them, killed the thief. If this happened with a stealer of food, still more would it be likely to happen with a stealer of women, when the tribe robbed was the more powerful.

Nothing of much importance is to be said respecting exogamy and endogamy in their general bearings on social life.

Exogamy in its primitive form is clearly an accompaniment of the lowest barbarism; and it decreases as the hostility of societies becomes less constant, and the usages of war mitigated. That the implied crossing of tribal stocks, where these tribal stocks are very small, may be advantageous, physiologically, is true; and exogamy may so secure a benefit which at a later stage is secured by the mingling of conquering and conquered tribes; though none who bear in mind the thoughtlessness of savages will suppose such a benefit to have been contemplated. But the exogamous custom, as at first established, implies an extremely abject condition of women; a brutal treatment of them; an entire absence of the higher sentiments that accompany the relation of the sexes. Associated with the lowest type of political life, it is also associated with the lowest type of domestic life.

Evidently endogamy, which at the outset must have characterized the more peaceful groups, and which has prevailed as societies have become less hostile, is a concomitant of the higher forms of the family.

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PROFESSOR HUXLEY'S LECTURES.[1]

III.

THE DEMONSTRATIVE EVIDENCE OF EVOLUTION.

IN my last lecture, I had occasion to place before you evidence derived from fossil remains, which, as I stated, was perfectly consistent with the doctrine of evolution, in fact, was favorable to it, but could not be regarded as the highest kind of evidence, or as that sort of evidence that we call demonstrative.

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[1] The last of three lectures on "The Direct Evidence of Evolution," delivered at Chickering Hall, New York, September 20th. From the report of the *New York Tribune*, carefully revised by Prof. Huxley.

I pointed out, in fact, that, as we go back in time, the great intervals which at present separate some of the larger divisions of animals become more or less completely obliterated by the appearance of intermediate forms, so that if we take the particular case of reptiles and birds, upon which I dwelt at length, we find in the mesozoic rocks animals which, if ranged in series, would so completely bridge over the interval between the reptile and the bird that it would be very hard to say where the reptile ends and where the bird begins. Evidence so distinctly favorable to evolution as this is far weightier than that upon which men undertake to say that they believe many important propositions; but it is not the highest kind of evidence attainable for this reason, that, as it happens, the intermediate forms to which I have referred do not occur in the exact order in which they ought to occur, if they really had formed steps in the progression from the reptile to the bird; that is to say, we find these forms in contemporaneous deposits, whereas the requirements of the demonstrative evidence of evolution demand that we should find the series of gradations between one group of animals and another in such order as they must have followed if they had constituted a succession of stages, in time, of the development of the form at which they ultimately arrive. In other words, the complete evidence of the evolution of the bird from the reptile—what I call the demonstrative evidence, because it is the highest form of this class of evidence; that evidence should be of this character, that in some ancient formation reptiles alone should be found; in some later formations birds should first be met with; and in the intermediate strata we should discover in regular succession those forms which I pointed out to you which are intermediate between reptiles and birds.

The proof of evolution cannot be complete until we have obtained evidence of this character, and that evidence has of late years been forthcoming in considerable and continually increasing quantity. Indeed, it is somewhat surprising how large is the quantity of that evidence, and how satisfactory is its nature, if we consider that our obtaining such evidence depends upon the occurrence in a particular locality of an undisturbed series deposited through a long period of time, which requires the further condition that each of these deposits should be such that the animal remains imbedded in them are not much disturbed, and are imbedded in a state of great preservation. Evidence of this kind, as I have said, has of late years been accumulating largely, and in respect to many divisions of the animal kingdom. But I will select for my present purpose only one particular case, which is more adapted to the object I have in view, as it relates to the origin, to what we may call the pedigree, of one of our most familiar domestic animals—the horse. But I may say that in speaking of the origin of the horse I shall use that term in a general sense as equivalent to the technical term *Equus*, and meaning not what you ordinarily understand as such, but also asses and their modifications, zebras, etc. The horse is in many ways a most remarkable animal, inasmuch as it presents us with an example of one of the most perfect pieces of machinery in the animal kingdom. In fact, among mammals it cannot be said that there is any locomotive so perfectly adapted to its purposes, doing so much work with so small a quantity of fuel, as this animal—the horse. And, as a necessary consequence of any sort of perfection, of mechanical perfection as of others, you find that the horse is a beautiful creature, one of the most beautiful of all land-animals. Look at the perfect balance of its form, and the rhythm and perfection of its action. The locomotive apparatus is, as you are aware, resident in its slender fore and hind limbs; they are flexible and elastic levers, capable of being moved by very powerful muscles; and, in order to supply the engines which work these levers with the force which they expend, the horse is provided with a very perfect feeding apparatus, a very perfect digestive apparatus.

Without attempting to take you very far into the region of osteological detail, I must nevertheless—for this question depends upon the comparison of such details—trouble you with some points respecting the anatomical structure of the horse, and more especially with those which refer to the structure of its fore and hind limbs. But I shall only touch upon those points which are absolutely essential to the inquiry that we have at present put. Here is the fore-leg of a horse: The bone which is cut across at this point is that which answers to the upper-arm bone in my arm, what you would call the humerus. This bone corresponds with my forearm. What we commonly term the knee of the horse is the wrist; it answers to the wrist in man. This part of the horse's leg answers to one of the human fingers, and the hoof which covers this extended joint answers to one of my nails.

You observe that, to all appearance, there is only one bone in the forearm. Nevertheless, at the upper end I can trace two separate portions; this part of the limb, and the one I am now touching. But as I go farther down it runs at the back part into the general bone, and I cease to be able to trace it beyond a certain point. This large bone is what is termed the radius, and answers to the bone I am touching in my arm, and this other portion of bone corresponds to what is called the ulna. To all appearance in the forearm of the horse the ulna is rudimentary, and seems to be fused into one bone with the radius.

It looks thus as if the ulna, running off below, came to an end, and it very often happens in works on the anatomy of the horse that you find these facts are referred to, and a horse is said to have an imperfect ulna. But a careful examination shows you that the lower extremity of the ulna is not wanting in the horse. If you examine a very young horse's limb you will find that this portion of the bone I am now showing you is separable from the rest, and only unites as the animal becomes older, and this is, in point of fact, the lower extremity of the ulna; so that we may say that in the horse the middle part of the ulna becomes rudimentary and unites with the radius, and that the lower extremity of the ulna is so early united with the lower extremity of the radius that every distinct trace of separation has vanished in the adult.

I need not trouble you with the structure of this portion that answers to the wrist, nor with a more full description of the singular peculiarities of the part, because we can do without them for the present, but I will go on to a consideration of the remarkable series of bones which terminates the fore-limb. We have one continuous series in the middle line which terminates in the coffin-bone of the horse upon which the weight of the fore-part of the body is supported. This series answers to a finger of my hand, and there are good reasons—perfectly valid and convincing reasons, which I need not stay to trouble you with—which prove that this answers to the third finger of my hand enormously enlarged.

And it looks at first as if there were only this one finger in the horse's foot. But, if I turn the skeleton round, I find on each side a bone shaped like a splint, broad at the upper and narrow at the lower end, one on each side. And those bones are obviously and plainly and can be readily shown to be the rudiments of the bones which I am now touching in my own hand—the metacarpal bones of the second and of the fourth finger—so that we may say that in the horse's fore-limb the radius and ulna are fused together, that the middle part of the ulna is excessively narrow, and that the foot is reduced to the single middle finger, with rudiments of the two other fingers, one on each side of it. Those facts are represented in the diagram I now show you of the recent horse. Here is the fore-limb (pointing to the diagram), with the metacarpal bones and the little splint-bones, one on each side. It sometimes happens that by way of a monstrosity you may have an existing horse with one or other of these toes—that is, provided with its terminal joints.

Let me now point out to you what are the characteristics of the hind-limb. This (pointing to the diagram) is the shin-bone of the horse, and it appears at first to constitute the whole of the leg. But there is a little splint at this point which is the rudiment of the small bone of the leg—what is called the fibula—and then there is connected with the lower end of the tibia a little nodule which represents the lower end of the fibula, in just the same way as that little nodule in the fore-limb represents the lower end of the ulna. So that in the leg we have a modification of the same character as that which exists in the fore-limb—the suppression of the greater part of the small bone of the leg and the union of its lower end with the tibia. So, again, we find the same thing if we turn to the remainder of the leg.

This (showing) is the heel of the horse, and here is the great median toe, answering to the third toe in our own foot; and here we have upon each side two little splint-bones, just as in the fore-limb, which represent the rudiments of the second and the fourth toes—rudiments, that is to say, of the metatarsal bones, the remaining bones having altogether vanished. Let me beg your attention to these peculiarities, because I shall have to refer to them by-and-by. The result of this modification is, that the fore and hind limbs are converted into long, solid, springy, elastic levers, which are the great instruments of locomotion of the horse.

As might be expected, and as I have already said, the apparatus for providing this machine with the fuel which it requires is also of a very highly differentiated character. A horse has, or rather may have, forty-four teeth, but it rarely happens that in our existing horses you find more than forty—for a reason which I will communicate directly—and in a mare it commonly happens that you find no more than thirty-six, because the "tushes," or canine teeth, of the mare are rarely developed. Then there are some curious peculiarities about these teeth. As every one who has had to do with horses knows, the cutting teeth—the incisors—are six above and six below, and those incisors present what is called a "mark;" at least, that mark is usually present in horses up to a certain age. It is a sort of dark patch across the middle of the tooth. The presence of that dark patch arises from a great peculiarity in the structure of the horse's incisor tooth. It is in fact considerably curved, with a deep pit in the middle of the crown, and then a long fang. In the young foal this pit is very deep. As the animal feeds, this pit becomes filled up with its fodder, that fodder becomes more or less carbonized, and then you have the dark mark, and the reason the dark mark serves as an indication of age, for, as the horse feeds, this is more and more worn down, until at last, in an aged horse, the tooth is worn beyond the bottom of the pit, and the mark disappears. Then, as I said, the male horse generally has canine teeth. We need not notice their structure particularly. Following that, you may occasionally notice a very small and rudimentary tooth, but it is very often absent. It really represents the first tooth of the grinding series. Then there follow six great teeth, with exceedingly long crowns. The crowns, in fact, are so long that the teeth take a very long time to wear down, whence arises the possibility of the great age to which horses sometimes attain. This is shown in the side diagram. Then the pattern and structure of a horse's tooth are very curious. The crown of the horse's tooth presents a very complicated pattern; that is to say, supposing this to be one of the grinders of the left side (illustrating) above, there is a kind of wall like a double crescent. Then there are two other crescents, which fall in that direction, and these are complicated by folds, and all the spaces between these crescentic ridges are filled up by a kind of bony matter which is called cement. Consequently the surface of the tooth is composed of very uneven materials—of the hard mass of the tooth, which is called dentine, then a very much harder enamel, and a softer cement between, the practical effect of which is the same as the lamination of the millstone. In consequence of the lamination of the millstone the ridges wear less swiftly than the intermediate substance, and therefore the surface always keeps rough and exerts a crushing effect upon the grain. The same is true of the horse's tooth, and consequently the grinding of the teeth one against the other, instead of flattening the surface of the teeth, tends to keep them always irregular, and that has a very great influence upon the rapid mastication of the hard grain or the hay upon which the horse subsists.

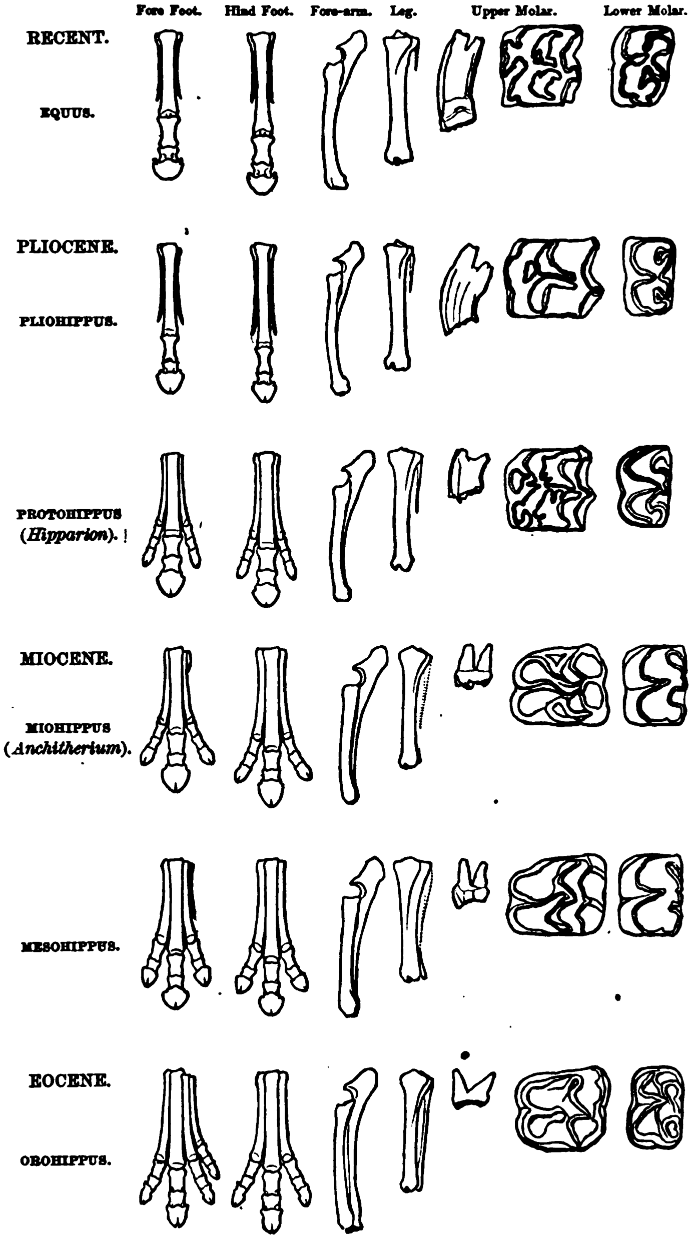
I think that will suffice as a brief indication of some of the most important peculiarities and characteristics of the horse. If the hypothesis of evolution is true, what ought to happen when we investigate the history of this animal? We know that the mammalian type, as a whole—that mammalian animals—are characterized by the possession of a perfectly distinct radius and ulna, two separate and distinct movable bones. We know, further, that mammals in general possess five toes, often unequal, but still as completely developed as the five digits of my hand. We know further that the general type of mammal possesses in the leg, not only a complete tibia, but a complete fibula—a complete, distinct, separable bone. Moreover, in the hind-foot we find, in animals in general, five distinct toes, just as we do in the fore-foot. Hence it follows a differentiated animal like the horse must have proceeded by way of evolution or gradual modification from a form possessing all the characteristics we find in mammals in general. If that be true, it follows that if there be anywhere preserved in the series of rocks a complete history of the horse, that is to say of the various stages through which he has passed, those stages ought gradually to lead us back to some sort of animal which possessed a radius, and an ulna, and distinct complete tibia and fibula, and in which there were five toes upon the fore-limb, no less than upon the hind-limb. Moreover, in the average general mammalian type, the higher mammalian, we find, as a constant rule, an approximation to the number of forty-four complete teeth, of which twelve are cutting teeth, four are canine, and the others are grinders. In unmodified mammals we find the incisors have no pit, and that the grinding teeth, as a rule, increase in size from that which lies in front toward those which lie in the middle or at the hinder part of the series. Consequently, if the theory of evolution be correct, if that hypothesis of the origin of living things have a foundation, we ought to find in the series the forms which have preceded the horse, animals in which the mark upon the incisor gradually more and more disappears, animals in which the canine teeth are present in both sexes, and animals in which the teeth gradually lose the complications of their crowns and have a simpler and shorter crown, while at the same time they gradually increase in size from the anterior end of the series toward the posterior. Let us turn to the facts and see how they bear upon the requirements of this doctrine of evolution.

In what is called here the Pliocene formation, that which constitutes almost the uppermost division of the tertiary series, we find the remains of horses. We also find in Europe abundant remains of horses in the most superficial of all these formations—that is, the post-tertiary, which immediately lies above the Pliocene. But these horses, which are abundant in the cave-deposits and in the gravels of England and Europe—these horses, of which we know the anatomical structure to perfection—are in all essential respects like existing horses. And that is true of all the horses of the latter part of the Pliocene epoch. But in the earlier Pliocene and later Miocene epoch, in deposits which belong to that age, and which occur in Germany and in Greece, in India, in Britain, and in France, we find animals which are like horses in all the essential particulars which I have just described, and the general character of which is so entirely like that of the horse that you may follow descriptions given in works upon the anatomy of the horse upon the skeletons of these animals. But they differ in some important particulars. There is a difference in the structure of the fore and hind limb, and that difference consists in this, that the bones which are here represented by two splints, imperfect below, are as long as the middle metacarpal bone, and that attached to the extremity of each is a small toe with its three joints of the same general character as the middle toe, only very much smaller, and so disposed that they could have had but very little functional importance, and that they must have been rather of the nature of the dew-claws such as are to be found in many ruminant animals. This *Hipparion*, or European three-toed horse, in fact presents a foot similar to that which you see here represented, except that in the European *Hipparion* these smaller fingers are farther back, and these lateral toes are of smaller proportional size.

But nevertheless we have here a horse in which the lateral toes, almost abortive in the existing horse, are fully developed. On careful investigation you find in these animals that also in the fore-limb the ulna is very thin, yet is traceable down to the extremity. In the hind-limb you find that the fibula is pretty much as in the existing horse. That is the kind of equine animal which you meet with in these older Pliocene and later Miocene formations, in which the modern horse is no longer met with. So you see that the *Hipparion* is the form that immediately preceded the horse. Now let us go a step farther back to the middle and older parts of which are called the Miocene formation. There you find in some parts of Europe the equine animals which differ essentially from the modern horse, though they resemble the horse in the broad features of their organization. They differ in the characters of their fore and hind limbs, and present important features of difference in the teeth. The forms to which I now refer are what constitute the genus *Anchitherium.* We have three complete toes; the middle toe is smaller in proportion, the inner and outer toes are larger, and in fact large enough to rest upon the ground, and to have functional importance—not an animal with two dew-claws, but an animal with three functional toes. And in the fore-arm you find the ulna a very distinct bone, quite readily distinguishable in its whole length from the radius, but still pretty closely united with it. In the hind-limb you also meet with three functional toes. The structure of the hind-foot corresponds with that of the fore-foot; but in the hind-leg the fibula is better developed. In some cases I have reason to think that it is complete; at any rate this lower end of it is quite distinctly recognizable. But the most curious change is that which is to be found in the character of the teeth. The teeth of the *Anchitherium* have, in the first place, so far as the incisors are concerned, a rudimentary pit. The canine teeth are present in both sexes. The molars are short; there is no cement, and the pattern is somewhat like this (drawing on the blackboard). In the upper jaw, there are two crescents and two oblique ridges, while in the lower jaw you have the double crescent. It is quite obvious that this (illustrating from drawing) is a simpler form than that. By increasing the complexity of those teeth there, we have the horse's teeth. These are all the forms with which we are acquainted respecting the past history of the horse in Europe. When I happened to occupy myself with this subject some years ago, notwithstanding certain difficulties, the facts left no doubt whatever in my mind that we had here a general record of the history of the evolution of the horse. You must understand that every one of these forms has undoubtedly become modified into various species, and we cannot be absolutely certain that we have found those species which constitute the exact line of modification, but it was perfectly obvious that we had here in succession, in time, three forms of the horse-type, of which the oldest came nearest to the general mammal. We saw that the forms which had existed afterward had undergone a reduction of the number of their toes, a reduction of the fibula, a more complete coalescence of the ulna with the radius. The pattern of the molar teeth had become more complicated and the interspaces of their ridges had become filled with cement. In this succession of forms you have exactly that which the hypothesis of evolution demands. The history corresponds exactly with that which you would construct *a priori* from the principles of evolution. An alternative hypothesis is hardly conceivable, but the only one that could be framed would be this, that the *Anchitherium*, the *Hipparion*, and the horse, had been created separately and at separate epochs of time. For that hypothesis there could be no scientific evidence, and it is not pretended that there is the slightest evidence of any other kind that such successive creation has ever taken place. When I was investigating this subject only the collections in Europe were accessible to me, but the materials they yielded led me to think that the horse must have descended from an *Anchitherium*-like ancestor, and I may say, as I happen to know by correspondence with him, that very eminent anatomist, the late Prof. Lartet, of Paris, had arrived independently at the same conclusion. Indeed, the story is so plain that no one deserves any particular credit for drawing so obvious a conclusion. And since then paleontological inquiry has not only given us greater and greater knowledge of the series of horse-like forms, but enabled us to fill up the gaps in the series, and to extend that series farther back in time.

That knowledge has recently come to us, and assuredly from a most unexpected quarter. You are all aware that when this country was first discovered by Europeans there were no traces of the existence of the horse in any part of the American Continent. And, as is well known, the accounts of the earlier discoveries dwell upon the astonishment of the natives when they first became acquainted with that astounding phenomenon—a man seated upon a horse. Nevertheless, as soon as geology began to be pursued in this country, it was found that remains of horses—horses like our European horses—like the horses which exist at the present day—are to be found in abundance in the most superficial deposits in this country, just as they are in Europe. For some reason or other—no feasible suggestion on that subject, so far as I know, has been made—but for some reason or other the horse must have died out on this continent at some period preceding—how long we cannot say—the discovery of America by the Europeans. Of late years there have been discovered on this continent—in your Western Territories—that marvelous thickness of tertiary deposits to which I referred the other evening, which gives us a thickness and a consecutive order of older tertiary rocks admirably calculated for the preservation of organic remains, such as we had hitherto no conception of in Europe. They have yielded fossils in a state of preservation and in number perfectly unexampled. And with respect to the horse, the researches of Leidy and others have shown that numerous forms of that type are to be found among these remains. But it is only recently that the very admirably contrived and most thoroughly and patiently worked-out investigations of Prof. Marsh have given us a just idea of the enormous wealth and scientific importance of these deposits. I have had the advantage of glancing over his collections at New Haven, and I can truly and emphatically say that, so far as my knowledge extends, there is nothing in any way comparable, for extent, or for the care with which the remains have been got together, or for their scientific importance, to the series of fossils which he has brought together. (Applause.) This enormous collection has yielded evidence of the most striking character in regard to this question of the pedigree of the horse. Indeed, the evidence which Prof. Marsh has collected tends to show that you have in America the true original seat of the equine type—the country in which the evidence of the primitive form and successive modifications of the horse series is far better preserved than in Europe; and Prof. Marsh's kindness has enabled me to put before you the following diagram, every figure in which is an actual representation of the specimen which is preserved in New Haven at this present time. The succession of forms which he has brought together shows, in the first place, the great care and patience to which I have referred. Secondly, there is this Pliocene form of the horse (*Pliohippus*); the conformation of its limbs presents some very slight deviations from the ordinary horse, and with shorter crown of the grinding teeth. Then comes the form which represents the European *Hipparion*, which is the *Protohippus*, having three toes and the forearm and leg and teeth to which I have referred, and which is more valuable than the European *Hipparion* for this reason: it is devoid of some of the peculiarities of that form—peculiarities which tend to show that the European *Hipparion* is rather a side branch than one in the direct line of succession. Next comes the *Miohippus*, which corresponds pretty nearly with what I spoke of as the *Anchitherium* of Europe, but which has some interesting peculiarities. It presents three toes—one large median and two lateral ones; of the toe which answers to the little finger of the human hand, there is only a rudiment. This is, however, as far as European deposits have been enabled to carry us with any degree of certainty in the history of the horse. In the American tertiaries, on the contrary, the series of equine forms is continued down to the bottom of the Eocene. The older Miocene form, termed *Mesohippus*, has three toes in front and a large splint-like rudiment representing the little finger, and three toes behind. The radius and ulna are entire, and the tibia and fibula distinct, and the teeth are anchitheroid with short crowns.

But the most important discovery of all is the *Orohippus*—which comes from the lower part of the Eocene formation, and is the oldest member of the equine series known. Here we have four complete toes on the front-limb, three toes on the hind-limb, a well-developed ulna, a well-developed fibula, and the teeth of simple pattern. So you are able, thanks to these great researches, to show that, so far as present knowledge extends, the history of the horse-type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution. And the knowledge we now possess justifies us completely in the anticipation that when the still lower Eocene deposits and those which belong to the Cretaceous epoch have yielded up their remains of equine animals, we shall find first an equine creature with four complete toes and a rudiment of the innermost toe in front, and probably a rudiment of the fifth toe in the


Fore Foot.
Hind Foot.
Fore-arm.
Leg.
Upper Molar.
Lower Molar.
RECENT.
EQUUS.
PLIOCENE.
PLIOHIPPUS.
PROTOHIPPUS
(*Hipparion*).
MIOCENE.
MIOHIPPUS
(*Anchitherium*).
MESOHIPPUS.
EOCENE.
OROHIPPUS.

hind-foot.[1] In still older forms the series of the digits will be more and more complete, until we come to the five-toed animals, in which most assuredly the whole series took its origin.

That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution. An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it. If that is not scientific proof, there are no inductive conclusions which can be said to be scientific. And the doctrine of evolution at the present time rests upon exactly as secure a foundation as the Copernican theory of the motions of the heavenly bodies. Its basis is precisely of the same character—the coincidence of the observed facts with theoretical requirements. As I mentioned just now, the only way of escape, if it be a way of escape, from the conclusions which I have just indicated, is the supposition that all these different forms have been created separately at separate epochs of time; and I repeat that of such an hypothesis as this there neither is nor can be any scientific evidence, and assuredly, so far as I know, there is none which is supported, or pretends to be supported, by evidence or authority of any other kind. I can but think that the time will come when such suggestions as these, such obvious attempts to escape the force of demonstration, will be put upon the same footing as the supposition made by some writers, who are, I believe, not completely extinct at present, that fossils are not real existences, are no indications of the existence of the animals to which they seem to belong; but that they are either sports of Nature or special creations, intended—as I heard suggested the other day—to test our faith. In fact, the whole evidence is in favor of evolution, and there is none against it. And I say this, although perfectly well aware of the seeming difficulties which have been adduced from what appears to the uninformed to be a scientific foundation. I meet constantly with the argument that this doctrine of evolution cannot be correct, because it requires the lapse of a very vast period of time, and that the duration of life upon the earth thus implied is inconsistent with the conclusions arrived at by the astronomer and the physicist. I may venture to say that I am familiar with those conclusions, inasmuch as some years ago, when President of the Geological Society of London, I took the liberty of criticising them, and of showing in what respects, as it appeared to me, they lacked complete and thorough demonstration. But, putting that point aside altogether, suppose that, as the astronomers, or some of them, and some physical philosophers, tell us, it is impossible that life could have endured upon the earth for as long a period as is required by the doctrine of evolution—supposing that to be proved, what I want to know is, what is the foundation for the statement that evolution does require so great a time? The biologist knows nothing whatever of the amount of time which may be required for the process of evolution. It is a matter of fact that those forms which I have described to you occur in the order which I have described in the tertiary formation. But I have not the slightest means of guessing whether it took a million of years, or ten millions, or a hundred millions, or a thousand millions of years, to give rise to that series of changes. As a matter of fact, the biologist has no means of arriving at any conclusion as to the amount of time which may be needed for a certain quantity of organic change. He takes his facts as to time from the geologist. The geologist, taking into consideration the rate at which deposits are formed and the rate at which denudation goes on upon the surface of the earth, arrives at certain more or less justifiable conclusions as to the time which is required for the deposit of a certain amount of rocks, and if he tells me that the tertiary formations required 500,000,000 years for their deposit, I suppose he has good ground for what he says, and I take that as the measure of the duration of the evolution of the horse from the *Orohippus* up to its present condition. And, if he is right, undoubtedly evolution is a very slow process, and requires a great deal of time. But suppose, now, that an astronomer or a physicist—for instance, my friend Sir William Thomson—comes to me and tells me that my geological friend is quite wrong, and that he has capital evidence to show that life could not possibly have existed upon the surface of the earth 500,000,000 of years ago, because the earth would have been too hot to allow of life, my reply is: "That is not my affair; settle that with the geologist, and when you have come to an agreement between yourselves I will adopt your conclusion." We take our time from the geologist, and it is monstrous that, having taken our time from the physical philosopher's clock, the physical philosopher should turn round upon us, and say we are going too fast. What we desire to prove is, is it a fact that evolution took place? As to the amount of time it took, we are in the hands of the physicist and the astronomer, whose business it is to deal with those questions.

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[1] Since this lecture was delivered, Prof. Marsh has discovered in the lowest Eocene deposits of the West a new genus of equine mammals (*Eohippus*), which corresponds very nearly to this description.—*American Journal of Science*, November, 1876.

I think, ladies and gentlemen, that I have now arrived at the conclusion of the task which I set before myself when I undertook to deliver these lectures before you. My purpose has been, not to enable those of you who have not paid attention to these subjects before to leave this room in a condition to decide upon the validity or the invalidity of the hypothesis of evolution, but to put before you the principles by which all such hypotheses must be judged; and, furthermore, to make apparent to you the nature of the evidence and the sort of cogency which is to be expected and may be obtained from it. To this end I have not hesitated to regard you as genuine students and persons desirous of knowing the truth. I have not hesitated to take you through arguments, even long chains of arguments, that I fear may have sometimes tried your patience, or to have inflicted upon you details which could not possibly be escaped, but which may well have been wearisome. But I shall rejoice—I shall consider I have done you the greatest service which it was in my power in such a way to do—if I have thus convinced you that this great question which we are discussing is not one to be dealt with by rhetorical flourishes or by loose and superficial talk, but that it requires the keenest attention of the trained intellect and the patience of the most accurate observer. When I commenced this series of lectures, I did not think it necessary to preface them with a prologue, such as might be expected from a stranger and a foreigner; for, during my brief stay in your country, I have found it very hard to believe that a stranger could be possessed of so many friends, and almost harder to imagine that a foreigner could express himself in your language in such a way as, to all appearances, to be so readily intelligible; for, so far as I can judge, that most intelligent, and, perhaps, I may add most singularly active and enterprising body, your press reporters, do not seem to have been deterred by my accent from giving the fullest account of everything that I happen to have said. But the vessel in which I take my departure to-morrow morning is even now ready to slip her moorings; I awake from my delusion that I am other than a stranger and a foreigner. I am ready to go back to my place and country, but, before doing so, let me, by way of epilogue, tender to you my most hearty thanks for the kind and cordial reception which you have accorded to me; and let me thank you still more for that which is the greatest compliment which can be afforded to any person in my position—the continuous and undisturbed attention which you have bestowed upon the long argument which I have had the honor to lay before you.

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THE STUDY AND TEACHING OF BIOLOGY.[1]

By Professor H. NEWELL MARTIN, D. Sc., M. B., B. A.

WE meet to-morrow to formally begin the biological work of this University—to commence that systematic study of animal and vegetable form and function, relationship and distribution, which we include under the names of Comparative Anatomy, Zoölogy, Physiology and Botany, or in the general terms Biology or Natural History. I have thought that it might be well to-day to take an opportunity of laying before you what seem to be the ends which we should hold in view, and the methods on which we should work, if we are to attain or to deserve a permanent success. I am further induced to take this course by the fact that our present year's work is confessedly of a tentative nature: one main object of it being to enable us to decide upon what lines we are to go forward in the future; and I believe it may facilitate decision on some points if we have before us, as a sort of basis for discussion, a definite statement of views on the subject, no matter how imperfect such statement may be in itself, or how much the opinions expressed in it may afterward be found to require modification. What I propose, therefore, is not simply to tell you what are our arrangements for this year, but also to put before you some thoughts as to what I think we ought to do in the time to come. It is, I am sure, unnecessary for me to dilate at any length, before this audience, upon the interest and importance of biological studies. However contributory to our culture and welfare other studies may be, biology has, and ever must have, a very special interest of its own: it alone deals with the living organisms which surround us, and which are the only things that share with us that wonderful collocation and interaction of natural forces which we call *life*. Biology, too, includes within its range the study of man himself, so far as one side of his nature is concerned; and, as regards his mental and moral qualities, the psychologist and sociologist have already begun to recognize that the progress of their sciences is closely bound up with the development of certain branches of biology. As regards its practical value I might set forth at length the indebtedness of scientific medicine and of sanitary science to biology; but I prefer not to recommend the study to you by such considerations. This is a university: and the object of a university, I take it, is directly to promote liberality of thought and culture, and only indirectly to concern itself with the practical advancement of material welfare. It is concerned rather with the acquirement of a knowledge of principles than with their practical applications; although, in connection with it, it may have subsidiary schools where those who have already learned the principles may acquire a practical knowledge of various arts. Nevertheless it is true that, if we devote ourselves to the higher objects, the rest will be added unto us; for it is one of the great glories of all the physical sciences that, while second to none in the training which a study of them gives to all the faculties of the mind—in the promotion of large and liberal ideas, and in the gratification of that longing to "know," which is the noblest characteristic of the human intellect—they at the same time, as a by-thing, but constantly, contribute to the increase of man's comfort, and to the material prosperity and happiness of his race. Those who advance our knowledge of the laws of animal and vegetable life may work without any immediate outlook to the advancement of medicine, hygiene, and agriculture, but such advancement constantly follows and springs from their work, and will ever do so.

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[1] An introductory lecture delivered at the Johns Hopkins University, October 28, 1876.

To those who are in any degree acquainted with the state of the scientific world, the present must seem a specially opportune time for founding a biological school. At no previous period has such an interest been taken in biological problems, or have so many earnest workers been in the field—never before has so rich a harvest been in view. This is mainly owing to the promulgation of two great ideas within the last few years. On the morphological side we have the doctrine of evolution applied to living forms, and especially as definitely put forward by the theory of the origin of species by natural selection; while on the physiological side we have the doctrine of the conservation of energy, and its extension to the play of forces in living organisms. It matters not whether these theories be correct representations of the facts or not, or whether increase of knowledge confirms or upsets them—in any case they have been of incalculable importance in stimulating work and in giving a present and direct significance to its results. I can imagine no time for the biologist to live in which would be more interesting than the coming half-century, or none in which he will have a greater incentive to study; he seems to have almost within his grasp the solution of problems of the widest significance.

Those of us directly concerned in the administration of the biological laboratory here, are charged with the fulfillment of two duties: we have to make provision for the advancement of knowledge, and for its diffusion; we are to find accommodation and assistance for both investigators and students; while we must not suffer those engaged in research to be crowded out by beginners, neither must the beginners be overlooked in providing for those to whom they are one day to succeed. The liberal space at our disposal will permit us, at any rate for the present, to accommodate both classes of workers, without risk of the extermination of either. Meanwhile I have, then, to occupy your time with a few words on two subjects: on biological research, and on biological teaching.

One hears a good deal talked nowadays of scientific research, and among it a good deal of what I cannot but think mischievous nonsense about the peculiar powers required by scientific investigators. To listen to many, one would suppose that the faculty of adding anything whatever to natural knowledge was one possessed by extremely few persons. I believe, on the contrary, that any man possessed of average ability and somewhat more than average perseverance, is capable, if he will, of doing good original scientific work. Any hard-working and commonly intelligent man, who likes his profession, will make a good soldier, or lawyer, or doctor, though that combination of powers which makes the great general, or the great jurist, or the great physician, is given to but few.

So it is with the pursuit of Science: assuredly not every one of her followers, very probably not one among us now present, will become a Linnæus, or a Cuvier, or an Agassiz. It may not be given to any of us to make some brilliant discovery, or to first expound some illuminating generalization; but we can, each and all, if we will, do good and valuable work in elucidating the details of various branches of knowledge. All that is needed for such work, besides some leisure, intelligence, and common-sense (and the more of each the better), is undaunted perseverance and absolute truthfulness; a perseverance unabated by failure after failure, and a truthfulness incapable of the least perversion (either by way of omission or commission) in the description of an observation or of an experiment, or of the least reluctance to acknowledge an error once it is found to have been made. Moreover, this love of truth must extend to a constant searching and inquisition of the mind, with the perpetual endeavor to keep inferences from observation or experiment unbiased, so far as may be, by natural predilections or favorite theories. Perfect success in such an endeavor is, perhaps, unattainable, but the scientific worker must ever strive after it; theories are necessary to guide and systematize his work, and to lead to its prosecution in new directions, but they must be servants, and not masters. I may, perhaps, seem to be insisting at too great length on a self-evident point; but the more one knows of scientific work and workers, the more does one realize the importance and the difficulty of attaining a perfectly-balanced mind and of arriving at an unprejudiced deduction from observation.

I believe, then, that the only absolutely necessary faculties for the scientific investigator are love of his work, perseverance, and truthfulness; to make the great leader and master in science, one of those who cast a new ray of light on our conceptions of the universe, other and far rarer powers are, of course, needed—the most essential being originality of thought; and, as that cannot be either self-taught or taught from outside but must be born in the bone, all that the rest of us can do when we meet such men is to give them a free course and ungrudging help. That an army may attain its best success, needs indeed that every man be brave and loyal, but it is by no means requisite that every soldier be a brigadier-general; so in the army of Science there is place for soldiers of all ranks and capabilities—and, at any rate, we know this, that Nature reveals her secrets, which are her rewards, on no system of purchase or favoritism—what a man deserves that he gets, every drummer-boy who enters her service carries the marshal's *bâton* in his pocket. His reward will be proportionate to the amount of time and intelligence he devotes to his work; given, in addition, certain opportunities which every one has not for himself, but which it is one great object of such institutions as this to provide for all.

If what I have just stated be the general requisites of the scientific investigator, we have next to inquire what special needs has the biologist: these may all be grouped under the head of preliminary training. He must have a fair knowledge of mechanics, experimental physics, and chemistry; he ought to (I would almost again say he *must*) be able, besides English, to read at least French and German with facility—assuredly, if he cannot, he will labor with much toil and sorrow—and the more mathematics he knows, with the present rapid importation of quantitative ideas into biological science, the better for him; and for certain special branches of biological work there are other special needs. No mistake is more disastrous than the idea that a man can be a botanist and nothing more; a zoölogist, and nothing more; a physiologist, and nothing more. It is true that no one can be master of all the physical sciences, but it is none the less true that hardly one of them can be entirely neglected by the biologist. Animals and plants are, after all, material objects, and live in accordance with the laws that govern matter; but the manifestations of these laws are so often obscured and complicated by the conditions in which they occur in living things, that the understanding of them is only to be got at by approaching them through their simpler manifestations in inorganic bodies. But, apart from that, definite knowledge of various sciences is constantly required by the biologist. How can one ignorant of physics have any real appreciation of the statement that the transmission of a nervous impulse is accompanied by a molecular alteration in the structure of a nerve-fibre, one sign of which is a certain very definite and peculiar alteration in its electrical properties; or how can one ignorant of chemistry grasp the fundamental statement that muscular work is in the long-run dependent on the breaking down of complex chemical molecules into simpler and more stable ones? How can the zoölogist or botanist scientifically study the distribution of animals and plants in space, unless he has a knowledge of physical geography; or in time, unless he knows something of geology? I need not prolong the list.

Furthermore, no one can properly study any branch of biology without some knowledge of its other divisions. The fundamental laws of animal and vegetable life are identical, and only fully realized by comparison; so, while the scientific botanist, to fully appreciate the facts of his own science, must be something of a zoölogist, so must the zoölogist know something of plants: no one living being or group of living beings can be properly understood by itself. To take other examples: how is the morphologist to deal with such problems as those presented to him by rudimentary organs, unless he know something of the functions of parts, which is the special domain of physiology; or, how is he to understand the influence of external conditions in the production and preservation of variations in force, without, again, this knowledge of function? And, as regards the physiologist, he has frequently to search the whole animal and vegetable kingdoms not only to discover those forms which give him the best opportunity of studying certain phenomena, but also to get at those fundamental ideas which lie at the base of his whole science. What general and broad ideas should we have of the contractility of protoplasm if we only knew it in the highly-specialized form of a muscular contraction; or of its irritability, if we only knew it as exhibited in the nervous apparatus of one of the higher animals? It is quite true that, without any breadth of knowledge, a man may collect, label, and store away thousands of plants; he may macerate and articulate the most beautiful skeletons; he may cut, stain, and mount, the most exquisite microscopic preparations: but assuredly he is not likely to do any work entitled to the name scientific; such mechanical work has its value, no doubt, but it is only preliminary to real scientific work—which latter requires wide knowledge and extended views, and is more valuable the broader the foundation on which it has been built up.

It is this mutual dependence of biological studies which appears to me the justification of grouping together, as we do here, the study of such a number of vast subjects in a single laboratory. By that means each investigator will receive knowledge and assistance from the other; under such a system the desirable intercommunication of ideas is rendered most easy; and we are most likely to escape that narrow specialism which every laboratory in the long-run has a tendency to get into. Of course, no one person is capable of giving detailed assistance in investigations in all the branches of biology; but our staff of professors will doubtless grow, and meantime we shall, I trust, by the associate and fellowship system of the university, have at all times among us well-qualified men in every branch of biology; so that no one fitted for the task, and earnest and willing in its prosecution, who may come here to undertake any special research, will fail to find some one able and willing to advise him when he needs advice, and to assist him when he needs assistance.

What we want here, then, is men with the requisite zeal and training for investigation—we care not whether classification, or morphology, or physiology, or any other branch of biology is their specialty; all we claim is that they shall be able to work, shall mean to work, and shall work—we shall give no quarter to the indolent or ignorant: the former we will not have on any terms, and the latter must enter for the preparatory courses, and will not be allowed to occupy tables set apart for research. Surely, if we select wisely, and find men to work faithfully, we may look forward with confidence to the time when we shall find ourselves in the condition of such laboratories as those of some of the German universities, where, on account of the high class of work done in them, the ablest young men from all over the world beg for admission; where one finds, working side by side, men from every civilized nation, and where, in the presence of the great demand for admission, entry is esteemed a precious privilege.

As to the special aid which we can offer to those who come among us to engage in investigation, it will, of course, depend on two factors, upon the natural gifts of those charged with the supervision of the laboratory, and the amount of money which those whose duty it is to decide on such matters see right to place at their disposal: for, however important we biologists may think ourselves, the fact remains that there are other studies to be provided for, and studies just as important as our own. For the present I can say, however, that we have at our disposal one large and well-lighted room for general work—a room fitted up for physiologico-chemical investigations—and several smaller rooms for physiological and histological research. As regards instruments we have ordered, and in part received, a very excellent stock, including the most essential ones for every branch of physiological research—and I have no doubt that every year we shall receive grants to add to our stock, and keep up with the times.

The zoölogical and comparative anatomy departments differ from the physiological in not needing so many special instruments; what they mainly need are (besides work-rooms) material for examination and dissection, and books, especially monographs, and those we shall make it a point, to the best of our power, to obtain from time to time as they are wanted. It seems to me that it is not our duty to provide vast herbaria and museums containing every plant and animal under the sun—to provide such collections is the duty rather of the nation than of a university—nor do I think we should be wise to collect and store away things promiscuously, in the hope that some one will want them some time. We should rather concentrate our force on getting what is wanted for the time being. If some one wants to elucidate any point in the structure of the Echinoderms, for example, we should do our best to obtain specimens for him—even from all parts of the world; if some one else wants to work at the embryology of any fish or amphibian, we should again endeavor to get him the eggs in various stages of development, and so on; but I doubt the wisdom of sending out collectors with orders to store away everything they can catch, fish, flesh, and fowl, in spirit, and send it to us. We have nowhere to display such collections if we got them—the vastly greater part of them would never be used—and when reference to extensive collections is necessary, we have always at hand the admirable museum illustrating the fauna and flora of this State which is being brought together by the Academy of Sciences in this city, and the national collections at Washington are within an hour's journey of us. Bringing together from time to time such materials for special researches as I have indicated above, will naturally entail considerable expenditure, but I am sure that the trustees, if they see we mean work, will do all they can to supply our needs.

Now let us turn to the other part of our subject, biological teaching: from part of what I have already said you have doubtless gathered something of my views on this matter. If biology be the complicated study that I have endeavored to indicate, it is in the first place clear that, in justice both to the student and his teachers, a certain preliminary training must be insisted upon as a preparation for his admission to a biological laboratory; at least the student must have a fair knowledge of physics and chemistry before he comes there; and, when he gets there, the thing next to insist upon is, that his teaching be as largely demonstrative and practical as possible, lectures being made of secondary and laboratory-work of primary importance.

It matters not to me where the student gets this preparatory knowledge; whether here or at some other institution. I believe he ought to acquire it largely at school, as a part of general education; but, as that seems in the present condition of primary education almost impossible, I shall perhaps best make clear my ideas on the matter if I endeavor to sketch out what I think should be the course gone through by a youth fresh from some high-school or college, where he has got an otherwise sound general education, but without anything more than a sham knowledge of physics, and who enters this university with the intention of qualifying himself for biological research or teaching hereafter; and you will, I hope, forgive me if, with the same object of obtaining clearness, I put what I have to say into a somewhat dogmatic form.

Such a person ought to enter at once upon courses of instruction in experimental physics and chemistry, and devote almost wholly his first year to them; but during the latter part of that year, say between the spring vacation and the end of the session, he would, in addition, go through a course of instruction in what we may call general biology. By that I mean a course of instruction in which he would acquire some knowledge of how to use his microscope and how to dissect, and thus gain a certain amount of that special manipulative dexterity which he will require afterward. He would also gain a general acquaintance with biological ideas, and with the meaning of the more important technical terms: he would gain, for example, a real, because a practical, knowledge of what we mean by classification, and of the principles on which classifications are founded; he would learn similarly, with his eyes as well as his ears, what we mean by morphology, and homology, and a host of similar terms; and he would, in addition, acquire a special acquaintance with the structure and actions of certain selected typical animal and vegetable forms. This, then, would finish the first year's work, unless our student should be ignorant of French and German. If so, he ought also to acquire, what is really very easily got, at least a fair reading knowledge of those languages.

At the commencement of his second year the student should enter for two elementary practical courses, one on comparative anatomy and zoölogy, the other on animal physiology. These courses would, I imagine, last about six months each, and they should be taken *pari* *passu.* Each would consist, say, of two lectures a week, and the rest of the time would be filled up with the dissection of typical animals, the performance of the simpler physiological experiments, and the preparation and examination of microscopic specimens of animal tissues, all illustrative of the main points put forward in the lectures. The student would also be made to draw sketches of his dissections and microscopic preparations, and to describe them and the results of his experiments briefly in writing, and so while learning thoroughly how to dissect and use his microscope, and the conditions of success in physiological experiment, he would also have his powers of observation regularly trained and tested.

In connection with these courses there should be a museum, containing not a bewildering multitude of specimens, but a small number of dissections and skeletons of typical animals, especially of those which it is important for the student to know, but which are too rare to be obtained in quantities allowing each to dissect one for himself; and these specimens should be so placed that they may be freely accessible to those desiring to study them. It is far better to have to replace an injured specimen occasionally than to have the things locked up behind glass doors, so as to render their thorough examination impracticable to those for whose examination they are placed there. Moreover, especially in connection with the physiological course, there would be needed from time to time, according to the subject-matter of the lectures, demonstrations of certain points; in cases, for instance, needing the employment of the more delicate instruments, or where niceties of manipulation were required, such as a beginner could not be fairly expected to overcome.

I ought perhaps here to refer to the subject of vivisection. Physiology is concerned with the phenomena going on in living things, and vital processes cannot be observed in dead bodies; and from what I have said you will have gathered that I intend to employ vivisections in teaching. I want, however, to say, once for all, that here, for teaching purposes, no painful experiment will be performed. Fortunately, the vast majority of physiological experiments can nowadays be performed without the infliction of pain, either by the administration of some of the many anæsthetics known, or by previous removal of parts of the central nervous system; and such experiments alone will be used here for teaching. With regard to physiological research the case is different: happily here too the number of necessarily painful experiments is very small indeed; but in any case where the furtherance of physiological knowledge is at stake—where the progress of that science is concerned, on which all medicine is based, so far as it is not a mere empiricism—I cannot doubt that we have a right to inflict suffering upon the lower animals, always provided that it be reduced to the minimum possible, and that none but competent persons be allowed to undertake such experiments. Placed, moreover, as we shall be here, in more or less close connection with a splendidly-equipped hospital, so that we shall be able constantly to combine skilled pathological observation with physiological experiment in an excellent laboratory, we have duties to perform toward the advancement of scientific medicine, from whose performance I believe it would be criminal in us, as it would be shameful, to flinch in any way.

But to return to our special subject: the last three months of the student's second year should be occupied with a laboratory course of instruction in vegetable morphology and physiology, and with a course of lectures on embryology, accompanied with a full practical study of the development of the chick from the earliest stages of incubation.

The student will have now got an extensive acquaintance with biological facts and methods, and henceforth he should be allowed and encouraged to specialize his work. He would be permitted to select for more detailed study in his third year either animal morphology, or botany, or physiology, and the best men in each subject would be picked out and allowed to act as demonstrators to the second-year students, and so be given the opportunity of acquiring a far more accurate knowledge than they could attain in any other way. For these third-year men, too, short advanced courses of lectures would be given from time to time, such as on the physiology of nutrition, the physiology of the senses, the geographical distribution of animals, on special morphological points, and so on, and also on the more important recent discoveries in various branches; and the best of them might be put on some easy bit of original work, to try their metal and whet their appetites.

After all this has been gone through, I think we can do no more in the way of teaching for our typical student; he has now advanced enough to teach himself, and, if he is good for anything, will do it better than others can do it for him. I think that among students so taught, as I have endeavored to indicate, we should be certain to meet with a large number of well-qualified men from among whom to select some of our fellows and associates, and would be justified in expecting from them work of the highest quality. As regards the remainder, those who display no special aptitude for scientific investigation, or no desire to devote themselves to science as a profession, they will at least have had the opportunity of acquiring a very thorough and practical knowledge of what modern biology means.

It now remains for me to give a sketch of what our work for the present year will be, so far as I see my way at present. To-morrow I commence a course of lectures on animal physiology, which I propose to deliver twice a week, on Tuesdays and Fridays, at 1.15 P. M. I have been induced to select this hour on account of special circumstances affecting many of those who wish to attend this year, though as a general rule I should like an earlier hour, nine or ten in the morning, which definitely brings a man early in the day to the laboratory, and gives me a better chance of getting a good day's work out of him. These lectures will be designed rather for those who have already some knowledge of physiology than for beginners; for so many instruments have not yet arrived, and so many arrangements are necessarily as yet imperfect, that it seems better for the present only to invite men who are more or less fitted by previous training to overcome such occasional difficulties and inconveniences as may from time to time arise from such causes. When I say that the lectures will be rather adapted for advanced students than beginners, I do not mean, however, that I shall omit elementary but important facts, but that, in addition to those, I shall from time to time discuss at more or less length points which are still *sub judice.* The lectures will be illustrated by no experiments: partly because, on account of the rapid changes which go on in living tissues, physiological-lecture experiments are likely to be the reverse of successful (a frog's muscle which has been lying on the table since the commencement of a lecture is very apt to contract abnormally when the lecturer wants it); but mainly because I want each student to make the illustrative observations and experiments for himself—except in cases of unusual difficulty, when demonstrations will be given at such hours as may be found most convenient to the majority. In the lectures I shall presuppose the possession by each present of such a knowledge of anatomy as is necessary for physiological work, and, starting with the structure of blood, go regularly on through the histology and physiology of the tissues and organs of the animal body. These lectures will continue until the spring vacation, and then I mean to set to work specially for more elementary students, and put them through such a course of general biology as I have already described; but possibly either Dr. Brooks or myself will give at that time some instruction in embryology of a more advanced character.

As regards physiological research, several gentlemen have already consulted me with reference to undertaking investigations in different directions, and of course there is plenty of work to be done should others qualified for it present themselves. One difficulty which I have met with is that many seem to consider that a physiological investigation can be carried on by devoting to it an hour or two at irregular intervals: I feel quite sure that no good work is likely to be done in that way, and am not inclined to encourage such workers. Some, at least, of those engaged in investigation will be able to have accommodation in the special rooms, apart from the general laboratory, which have been provided for that purpose.

On the zoölogical and morphological side no arrangements have as yet been made for a lecture and laboratory course this year, nor so far as I know has any such demand as would render it advisable shown itself. Should it do so, however, we may, perhaps, make arrangements for elementary instruction in those subjects, under the more immediate superintendence of Dr. Brooks, our associate in biology, upon whose shoulders I must throw most of the burden of that side of the work. We shall, at any rate, collect material and make other preparations for such a course next year. After Christmas Dr. Brooks will give a course of lectures on "Morphological Theories."

For the present, too, we shall have in the laboratory several well-trained zoölogists and morphologists; some engaged in prosecuting advanced studies, others in research. I fancy all of them are (as they ought to be) pretty well qualified to take care of themselves; but Dr. Brooks and myself will do our best to give them such assistance as they may need, and to make arrangements by which they can be supplied with such material as they require.

In conclusion, let me say a word to those of you here present who are to be the first workers with me in this laboratory. It behooves you as well as me to recognize what a heavy responsibility lies upon us. Upon the work that we do and the spirit in which we do it, upon the character we give our laboratory at its start, much of its future success or failure depends. If we all work honestly and thoroughly, it will win esteem and reputation; if we are careless and half-hearted, it will become of low repute. Let us, then, each work loyally, earnestly, truthfully, so that when the time comes, as it will come sooner or later, in one way or another, to each of us, to depart hence, we may carry with us a good conscience, and be able to say that in our time no slipshod piece of work ever left the laboratory; that no error we knew of was persisted in; that our only desire was to know the truth. Let us leave a record which, if it perchance contain the history of no great feat in the memory of which our successors will glory, will at least contain not one jot or one tittle of which they can be ashamed.

THE PARALLEL ROADS OF GLEN ROY.

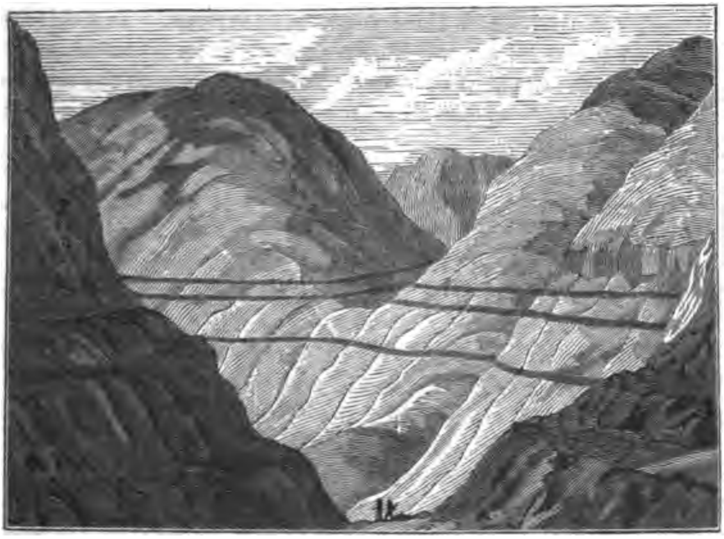
FROM a lecture recently delivered by Prof. Tyndall before the Royal Institution, we gather the following facts in regard to that natural wonder in Scotland, which for so long remained a puzzle to all investigators. There is an unusual interest centred around its history, from the time when the country-people explained it by their crude and half-mythical theories, to the time when it became a labor of love for the untiring efforts and acute observations of scientists.

The earliest published allusion to these roads was made in a work brought before the public a century ago, but no systematic description of them appeared before 1817. They are found in the district of

Lochaber, Inverness-shire. On both sides of the steep, narrow glen through which the Roy runs, there are three perfectly horizontal and parallel roads, directly opposite on each side, those on one side corresponding exactly in elevation to those on the other. They are respectively 1,150, 1,070, and 860 feet above the sea, and are formed as shelves in the yielding drift which covers the sides of the mountains. They usually slope somewhat from the hill, and vary in width from one to twenty yards. The two highest stop abruptly at different points near the mouth of Glen Roy, although no barrier now remains to show any reason for it. At some points the grass on the shelves differs from that which is above and below, and, as the roads lie in the midst of heather-covered hills, the absence of the dark shrub from them adds greatly to their conspicuousness.

The terraces were originally supposed to have been made for the heroes whose deeds have been sung by Ossian. A less romantic view was that "they were designed for the chase, and were made after the spots were cleared in lines from wood, in order to tempt the animals into the open paths after they were roused, in order that they might come within the reach of the bowmen who might conceal themselves in the woods above and below." In 1816 Playfair believed them to be aqueducts for artificial irrigation. In 1817 Dr. MacCulloch discussed the probability of there having been lakes embosomed in Glen Roy at one time, and supposed that these roads were the margins of the lakes. It remained, however, for Sir Thomas Dick-Lander to bring forward the facts of the subject, and place them in a scientific light. Adjacent to Glen Roy is Glen Gluoy, along the sides of which there is a single terrace or road, having the same elevation on each side of the valley, and similar in all respects to the roads of Glen Roy. Wishing to see whether these two sides would be united at the head of the glen, and in what manner, he followed them into the mountains. As the valley gradually rose, he observed the shelves approaching each other more nearly; and finally, at the head of Glen Gluoy, he discovered a water-shed of exactly the same elevation as the road which swept around the glen. This height was found to be 1,170 feet, or 20 feet higher than the upper road of Glen Roy. From this water-shed he passed through a lateral branch-valley to Glen Roy, descended to the highest road, and followed it up the glen as he had pursued the previous road. In the same manner he came upon a water-shed looking into Glen Spey, and of precisely the same elevation as the road. After this he dropped down to the lowest shelf, and followed it to the mouth of the glen. It did not end here, however, but doubled around the hills, and ran along the sides of the mountains which flank Glen Spean. Continuing eastward, he observed the Spean Valley gradually approaching the road until the two were on a level, when, as in the other cases, he discovered a water-shed.

From these facts, convinced that water alone could have produced the terraces, he saw that if the mouth of Glen Gluoy were stopped by a barrier, the waters from the surrounding mountains would be collected in the valley until they had reached the water-shed, when any further rise would be prevented by the branch-valley, which would carry the additional water off to Glen Roy. As long, then, as the barrier remained, there would be a lake in Glen Gluoy, at the exact level of the road, which, by constant action upon the loose drift, would be sufficient to produce the road. Now, if the mouth of Glen Roy should also be barred at the same time by a sufficiently high barrier, the waters would be collected behind it, the surface of the lake would rise till it reached the water-shed dividing Glen Roy from Glen Spey, when the superabundant water would flow into the latter valley. In this way the highest shelf of Glen Roy would be formed. If its barrier were now to be partly removed, so as to establish a connection between it and the upper part of Glen Spean, while the lower part remained blocked up, upper Glen Spean and Glen Roy would then be occupied by a continuous lake, the level of which would be determined by the water-shed discovered in Glen Spean. The water in Glen Roy would take a level corresponding to its new place of escape, and the lowest parallel road would be formed. The conclusions thus drawn would be strictly logical, if proof could be offered as to the existence of the barriers.



PARALLEL ROADS OF GLEN ROY.

In Glen Spean there is a large quantity of detritus, and Sir Thomas Dick-Lander supposed that this had at one time been heaped up by some unknown convulsion. As he could not account for the middle road of Glen Roy in the same manner, he assumed that at a certain point—the level of this road—the barrier which had been wasting away held its ground for a sufficiently long time to form the road. But, on the same principle, there would naturally have been a greater number of roads in this glen, and additional roads in the other glens. A weakness was thus admitted into the theory which was immediately attacked by Mr. Darwin. He believed that the whole region had once been covered by the sea, and that, in the upheaval of the earth, there were pauses during which these roads were formed. But this would not account for the sea being higher in one of the glens than in another, nor for the unequal number of terraces by which the mountains are belted. As soon as Mr. Darwin detected these fallible points, he abandoned his theory.

In 1847 the Dick-Lander hypothesis received new strength from a discovery made by Mr. Milne-Home. There is a lateral glen, called Glen Glaster, running eastward from Glen Roy, which had escaped the notice of Sir Thomas Dick-Lander. Mr. Milne-Home entered this glen, pursued a branch of it extending to the southeast, and came upon a water-shed exactly level with the second Glen Roy road. On the same theory as before, when the barrier should be properly removed, the water in Glen Roy would sink to the second road, and the surplus water would escape over the Glen Glaster water-shed into Glen Spean. But this mode of explanation could not yet be accepted, for there is scarcely a trace left of the immense quantity of detritus that would have been necessary to form the barriers. Nor could the detritus have been swept away by glaciers, for there have been no glaciers in these valleys since the retreat of the lakes.

At the time when Sir Thomas Dick-Lander was making his investigations, the action of ancient glaciers was not understood. The subject had been pursued in Switzerland, but it was not till 1840 that unmistakable marks of glacier-action were pointed out in Great Britain by Agassiz. He visited Glen Roy, and, having detected the traces of glaciers, pronounced these to have been the barriers blocking up the glens. This theory was afterward examined and confirmed by Mr. Jamieson. "It was their ascription to glacier-action," says Prof. Tyndall, "that first gave the parallel roads of Glen Roy an interest in my eyes; and in 1867, with a view to self-instruction, I made a solitary pilgrimage to the place, and explored pretty thoroughly the roads of the principal glen." At different places he found that the effects of the lapping of the water on the more friable portions of the rock are still perfectly distinct. Several months ago he again visited the place, prior to delivering a lecture upon the subject. The entire ground was thoroughly explored, and the principal hills were found to be intensely glaciated. The collecting-ground of these glaciers, which blocked up the valleys, were the mountains south and west of Glen Spean—among others, Ben Nevis. These lofty mountains encounter the southwestern Atlantic winds, and deprive them of their vapor. During the glacial epoch this vapor was precipitated as snow, which slid down the slopes, while every valley and recess kept up a constant supply of glaciers into Glen Spean, filling it to an ever-increasing height. There would of course be ice in Glen Spean, and water to the north of it, as the winds in passing north would be partly dried and warmed by the liberation of their latent heat. As long as the supply was in excess of the consumption, the dams closing the glens would increase in height. As the weather grew warmer, the opposite would be true. For a long time the conflict would continue, retarding indefinitely the disappearance of the barriers, but the ice in the end would have to give way. "The dam at the mouth of Glen Roy, which probably entered the glen sufficiently far to block up Glen Glaster, would gradually retreat. Glen Glaster and its water-shed being opened, the subsidence of the lake 80 feet, from the level of the highest to that of the second parallel road, would follow as a consequence." "In presence, then, of the fact that the barriers which stopped these glens to a height, it may be, of 1,500 feet above the bottom of Glen Spean, have dissolved, and left not a wreck behind; in presence of the fact insisted on by Prof. Geikie, that barriers of detritus would undoubtedly have been able to maintain themselves had they ever been there; in presence of the fact that great glaciers once most certainly filled these valleys—that the whole region, as proved by Mr. Jamieson, is filled with the traces of their action—the theory which ascribes the parallel roads to lakes dammed by barriers of ice has, in my opinion, an amount of probability on its side which amounts to a practical demonstration of its truth."

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SCIENCE IN AMERICA.[1]

BY PROFESSOR JOHN W. DRAPER, M. D., LL. D.

GENTLEMEN, MEMBERS AND ASSOCIATES OF THE AMERICAN CHEMICAL SOCIETY: In accordance with the plan of the American Chemical Society, I am called upon to address you this evening. I have to congratulate you on its successful establishment, and its prospect of permanent success.

Let us consider some of the reasons which would lead us to expect that success, not only for our own, but also for other kindred societies. The field of Nature is ever widening before us, the harvest is becoming more abundant and tempting, the reapers are more numerous. Each year the produce that is garnered exceeds that of the preceding.

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[1] Inaugural address before the American Chemical Society, delivered at Chickering Hall, New York, November 16, 1876.

In all directions there is good hope for the future. Perhaps, then, you will listen without impatience for a few minutes this evening to one of the laborers who has taken part in the toil of the generation now finishing its work, who looks back, not without a sentiment of pride, on what that generation has done, who points out to you the duties and rewards that are awaiting you, and welcomes you to your task. Let us look at the prospect before us.

The progress of science among us very largely depends on two elements: first, on our educational establishments; second, on our scientific societies. To each of these I propose to direct your attention; and, first, of our colleges:

Prof. Silliman, in his address delivered on the occasion of the centennial of chemistry, at the grave of Priestley, in commemoration of the discovery of oxygen, makes this remark: "The year 1845 marks the beginning of a new era in the scientific life of America, which is still in active progress, and chemistry has had its full share in this advance." He then enumerates the causes which, in his opinion, had brought about this increased activity. Among them are the centennial celebration of the American Philosophical Society, in Philadelphia, in 1843; the reorganization of the United States Coast Survey, in 1845; the establishment of the Smithsonian Institution at Washington, in 1846; the enlargement of the *American Journal of Science*, in the same year; the contemporaneous foundation of the Astronomical Observatory at Cincinnati; the institution of the Analytical Laboratory at Yale College, in 1847; and, simultaneously, the Lawrence Scientific School at Harvard. To these he adds especially the establishment of the American Association for the Advancement of Science, in 1848. Coinciding with him fully as to the character and power of these and other local causes which he mentions, I cannot but regard them as being themselves the issues of influences of a much more general kind.

A revolution had been taking place in Europe—a revolution not so much political as industrial or social, though it was followed by political consequences of the most important nature. Its commencements may be seen in the preceding century, in the canal-engineering of Brindley; in the improvements of iron-manufacture; in the construction of all kinds of machinery, which reached its acme when the hand of man was deposed from its office, and, through the slide-rest and planing-machine, engines were made by themselves. Then came the exquisite contrivances for the manufacture of textile fabrics, so that a man could do as much work in a day as he had formerly done in a year, the movement in that direction culminating in the two steam-engines, the condenser and non-condenser. The demand for cotton rose; the value of the slave, its cultivator, was enhanced; and the negro question became the paramount political question in the United States. See how scientific discoveries and inventions lead to political results! Herein, among other great events, we find the origin of the American civil war!

In Europe, the social effect of the use of steam was strikingly marked. Performing mechanical drudgery, it relieved vast numbers of the laboring-class, and gave them time to think. It concentrated them in factories and mills. Those industrial hives were pervaded by literary influences, perhaps not always of a kind that we should approve of. They became the seats of agitation in politics and theology, and, while this was the effect on the laboring mass, the owners or capitalists were accumulating enormous fortunes.

We may excuse the enthusiastic literature of the cotton-manufacture its boasting, for men had accomplished works that were nearly godlike. Mr. Baines, writing in 1833, states that "the length of cotton-yarn spun in one year was nearly five thousand millions of miles—sufficient to pass round the earth's circumference more than two hundred thousand times, sufficient to reach fifty-one times from the earth to the sun. It would encircle the earth's orbit eight and a half times. The wrought fabrics of cotton exported in one year would form a girdle for the globe, passing eleven times round the equator, and more than sufficient to form a continuous sheet from the earth to the moon." And let us not forget that, to give commercial value to this vast result, the capital chemical discovery of bleaching by chlorine was essential. Such was the condition of things in England just previously to the epoch in question. Necessarily, it was followed by great social results.

But there was something more. The locomotive absolutely revolutionized society. A man could now travel farther in an hour than he had previously done in a day. Again, it was clear that important political results were occurring. The effect of the railroad was to render nations more homogeneous, to destroy provincialism. It is actually true that language underwent a change. No one who has remarked the various dialects of the English counties prior to the opening of the Liverpool & Manchester Railway, and the homogeneousness of speech which is fast displacing them, can be blind to this. Simultaneously, a redistribution of the population took place. It was largely withdrawn from the open country, and concentrated in the towns.

In this statement I am recalling facts so common that they are familiar to us all. We all appreciate the immense social changes that took place just before 1845. Who in those times could fail to perceive that grand consequences must follow the expenditure of thousands of millions of dollars in the building of railroads, who, when he saw the labor of a year shrinking into the compass of a day, the travel of a day into the compass of an hour, the thought of man outstripping the velocity of light—who could be so obtuse as not to discern that a new agency had taken possession of the earth, that it was agitating the nations to their very foundations, that it was ameliorating the lot of man, increasing his power, and dealing remorselessly with old ideas, the fictions and fallacies of the past!

Can we wonder, then, that those who were growing up in the midst of these marvels should not only contrast the activity by which they were surrounded with the stagnation of preceding centuries, but should demand to be made acquainted with the power that was thus opening a new world before their eyes? Very soon it became apparent that there was no provision in the existing educational establishments, the universities and colleges, for this unexpected state of things. These were, to be sure, good enough to initiate a bench of boys into the method of translating an ode of Horace or a few lines of Sophocles, but something more substantial than that was wanted now.

This was the true cause of that influence which began to be felt in America about 1840. Every reflecting person saw that a change in public education was imperative; nay, more was impending. Confronted by the vigor of modern ideas, the system that had come down from the dark ages was seen to have become obsolete.

In addition to these influences, there was another at which we must for a moment glance. Let me, in a few words, sketch its history.

The peninsula of Italy was separated from the rule of the Greek emperors in the eighth century, mainly in consequence of the iconoclastic dispute. Partly through the stress of circumstances, and partly as a matter of policy, the Latin language was brought into such prominence that it was supposed to contain all the useful knowledge in the world. In Western Europe, at the close of the fourteenth century, Greek was totally forgotten.

But when it became clear that Constantinople would be taken by the Turks, many learned men fled to the West, bringing with their language precious classical manuscripts. As it was feared, however, by the dominant authority that knowledge and opinions of an unsuitable kind might thus be introduced, Greek obtained a foothold with much difficulty, and it was only by the aid of Florence, Venice, and other commercial towns of Upper Italy, that after a struggle it made good its ground. The Latin had now a successful rival.

A century later brings us to the culmination of the Reformation. Its literary issue was an admiration of the language of that much-enduring, that immortal race to whom the Old Testament is so largely due. As had been the case with Greek, so now Hebrew passed from a condition of neglect to one of extravagant exaltation. It was believed to have been the original language of the human race, a conviction that proved to be a great stumbling-block to the progress of learning. There were thus three classical languages, each having its own paramount claim.

In 1784 the Royal Asiatic Society was instituted in Bengal. One of its earliest and most important services was that it brought the Sanskrit language emphatically to the knowledge of Europe. The similarity of this to Latin and Greek, especially in the grammatical forms, struck every one with surprise. At first the old literary party resisted its claims, some of them even affirming that it never had been a spoken tongue, but that it had been fictitiously constructed out of Latin and Greek. The creation of comparative grammar by the great German scholar Bopp, in 1816, threw a flood of light on the subject; and the discovery in 1828, by Hodgson, of the Buddhistic sacred writings in Nepaul, revealed to astonished Europe a literature of grand antiquity and prodigious extent, in which is contained the religious belief of 400,000,000 men—ten times the present population of the United States. Greek and Latin had now to descend from the imperial thrones on which they had been seated, and take their places as later and less perfect forms of this wonderful Oriental tongue.

In the higher regions of literature all over Europe, these discoveries made a profound impression. It was at once seen by the great scholars of the times that the existing educational system, founded, as it so largely was, on the languages of the Mediterranean peninsulas, was altogether on an imperfect basis. They saw that philology was about to occupy a higher platform, and that, though it might cost a struggle with present interests, a change in public education was necessary. But though these languages have suffered an eclipse, there still remains that priceless heritage which they have transmitted to us—immortal examples in national life, in patriotism, in statesmanship, in jurisprudence, in philosophy, in poetry. Still there remain the ruins of the Parthenon, the relics of those statues which have no rival elsewhere in the world—embodiments of the beautiful, before which, even at the risk of being denounced as a pagan, a man might fall down and worship. Still there remains the history of that awful empire which once bore sway around the Mediterranean Sea, an empire to which we owe our civilization, our religious convictions, and even our modes of thought.

I add this great discovery in letters to the scientific and industrial movement I have described as bringing on the epoch of 1840.

Educational institutions are in their nature very much under the influence of the past. They are guided by men of the parting generation, and are essentially conservative. The changes they began to manifest did not originate within them, but were forced upon them from without. They clung to the mediæval as long as they could, and only accepted the modern when they were compelled.

Among American colleges which are emancipating themselves from the mediæval, we may number Columbia, Cornell, Harvard, Princeton, University of Virginia, Yale. Doubtless there are many others that would follow the example if they could, but they are fettered with the gyves of sectarian or local restraint. They march along, daintily and grotesquely, in the pointed shoes of the fourteenth century.

I linger on this subject of colleges because the example of other countries, and especially of Germany, proves to us that on them our hopes for the development of science must very largely rest. The scientific glory of Germany, not inferior in brilliancy to its military glory, is the creation of its university professors. Among them we find the great chemists and physicists, whose works we study with delight.

Our colleges must separate themselves from the mediæval, and assume thoroughly and sincerely the modern cast. Sincerely, I say, for not a few of them indulge in deception. They would have us believe that they teach physics when they have no modern apparatus; chemistry, when they have no laboratory; botany, without any garden, herbarium, or even drawings; geology, mineralogy, natural history, without any cabinets. So ignorant are some boards of trustees and faculties, that they hold such equipments as luxuries easily dispensed with. I have known some go so far as to affirm that as much money ought to be expended in teaching a few boys Latin and Greek as in giving a demonstrative and illustrated course of science, and even to act on that principle. In institutions under this kind of influence, you will always find that their whole weight is thrown toward the æsthetic. Whatever college honors there may be, whatever emoluments, pass in that direction; and, though through fear of public opinion science cannot be ignored, it is simply tolerated, not cultivated.

From our colleges we may in the second place turn to our scientific societies.

I have referred to the period at which the Greek language became cultivated in Western Europe. The first societies were those established in Florence by its admirers. In the Medicean gardens the lovers of Plato assembled to restore, under an Italian sky, the philosophy that had been extinguished in Athens, and to commemorate by a symposium the birthday of that illustrious man. There is a pleasure in associating with those whose thoughts are congenial to our own, in breathing an atmosphere in which the intellectual makes itself felt.

Very soon the example was imitated. Persons who had a love for science followed the example of those who had a love for letters. The *Academia Secretorum Naturæ* was instituted at Naples in 1560, by Baptista Porta, the inventor of the camera which photographers now so much use; the Lyncean Academy for the Promotion of Natural Philosophy, in 1603; the Royal Society of London, 1645; the Royal Academy of Sciences in Paris, 1666; the Berlin Academy of Arts and Sciences, in 1700. Leibnitz, the rival of Newton, was its first president.

When the Royal Society of London was founded it encountered a bitter opposition. Had it not been for the "merry monarch," Charles II., it must have succumbed beneath the fierce maledictions launched against it.

As in Italy, when the opportunity was offered, men of the same inclination of thinking sought each other, so here, to the surprise of the most enthusiastic chemists, when such an association was proposed, persons seeking membership came crowding in. The society I have the honor of addressing this evening was the result. Already it has completely organized itself; already it has published the first number of its "Proceedings," a publication which I am sure will procure for it approval and respect.

In these organizations of scientific effort, an opportunity of assisting is given to those who, not having dedicated themselves to philosophical pursuits, have yet achieved success in other walks of life, and who, recognizing that the progress of civilization very largely depends on the increase of knowledge, may desire to aid in promoting that great result by the application of their means. See what immense benefits have arisen from the money grants that foreign governments have placed at the disposal of their scientific bodies; see what a stimulus there has been in the award of medals of honor, and, if you desire to witness the effect of a well-judged benefaction, look at the Smithsonian Institution. I would not say one word in disparagement of gifts to colleges and universities, for it is indeed a noble purpose; but endowments for the promotion of a knowledge of Nature conferred on scientific societies for the good of all men, no matter what their country or color, no matter what their religious profession or political condition, are still nobler. The one is a local and transitory benefaction, the other an enduring and universal benevolence.

In our own special science, chemistry, all that has been done has only served to extend the boundary of what remains. The thousands of analyses that have been made have brought us into a wilderness of results. We have not been able to rise to a point of view sufficiently high to discover what is the true place of those results in Nature. We try to represent on the pages of our books and on our black-boards formulas of the constitution of things, conscious all the time that these are at the best only convenient fictions, which must necessarily change as we gain a more perfect insight into that grandest of all problems, the distribution of Force in Space, and the variations to which it is liable. The geometry of chemistry is that of three dimensions, not of two. We have to consider the relation of points not situated on one plane, and hence it is necessary to employ three axes of reference; nay, even more, we cannot avoid the conception of the mathematical method of quaternions. Our inadequate information respecting the real grouping of atoms is followed as a necessary consequence by imperfection in our methods of nomenclature, the confusion in this respect becoming, as we all too well know, every day worse and worse.

And now, while we have accomplished only a most imperfect examination of objects that we find on the earth, see how, on a sudden, through the vista that has been opened by the spectroscope, what a prospect lies beyond us in the heavens! I often look at the bright-yellow ray emitted from the chromosphere of the sun, by that unknown element, Helium, as the astronomers have ventured to call it. It seems trembling with excitement to tell its story, and how many unseen companions it has. And if this be the case with the sun, what shall we say of the magnificent hosts of the stars? May not every one of them have special elements of its own? Is not each a chemical laboratory in itself? Look at the cluster in the sword-handle of Perseus; in Cassiopeia, a universe of stars on a ground of star-dust; in Hercules—of which, as astronomers say, no one can look at for the first time through a great telescope without a shout of wonder—the most superb spectacle that the eye of man can witness! Look at the double stars of which so many are now known, emitting their contrasting rays, garnet, or ruby, or emerald, or sapphire. Each is in accordance with its own special physical conditions, though all are under the same universal ordinance.

Now, here a fact of surpassing importance presses itself on our attention. The movements taking place in those distant bodies are taking place under the same laws that prevail here on earth, and in our solar system. The law of gravitation, as developed by Newton, bears sway in all those distant worlds. In them bodies attract each other with forces directly as their masses and inversely as the squares of their distances. There the laws of the emission, absorption, and transmission of light are the same as they are with us. There ignited hydrogen gives forth its three rays, the same rays that it gives forth to us. In the uttermost parts of the universe the law of definite combination, the numerical law, and the multiple law, stand good. Sodium absorbs its two waves of definite refrangibility, and iron gives in the spectra its more than a hundred lines, more than a hundred silent but convincing witnesses of the uniformity of the constitution of the universe. There the number of vibrations that constitute a ray of definite refrangibility is the same we have found it to be here. In the enormous heat of those central suns the dissociation of molecules may be of a higher order than we can reach artificially, but the law under which it takes place is a continuation of the law here. There, though the weight of a given mass of matter is different from what it is with us, it is nevertheless determined by the law that determines here—the law of gravitation. There energy is indestructible, and is measured as it is measured among us, by work. Then is there any boundary that we can assign to natural law—is it not omnipresent, universal?

Perhaps there is no exaggeration in the assertion—for there seems abundant proof of its truth—that the light by which we see some of those distant orbs has crossed through such a prodigious space that millions of years have transpired during the journey. Then the phenomena it brings to us are those that were engendered in the beginning of the vast time so passed. Whatever there is that is in harmony with facts now happening here, is to us an unimpeachable evidence that the laws which were governing in those old ages have undergone no depreciation, but are active as ever until now. Then shall I exaggerate if I say that those laws are eternal in duration?

Infinite in influence, eternal in duration, what a magnificent spectacle! In the resistless energy of the motions of the universe is there not omnipotence? The Omnipotent, the Infinite, the Eternal, to what do these attributes belong?

Shall a man who stands forth to vindicate the majesty of such laws be blamable in your sight? Rather shall you not with him be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of Nature are only the passing thoughts of God.

But, grand as this is, there is something still grander. There is another temple into which we have to pass, not that of the visible but that of the invisible. We must persist in the invasion we have made, in the revolution we have brought about in physiology. We have to determine the laws which preside in the nervous system of man, and discover the nature of the principle that animates it. Is there not something profoundly impressive in this, that the human mind can look from without upon itself, as one looks at his phantom image in a mirror, and discern its own lineaments and admire its own movements? My own thoughts have of late years been forcibly drawn to this, from a recognition that the interpretation by the mind of impressions from without takes place under mathematical laws, as, for instance, that when external ethereal vibrations create in the mind a certain idea, that same idea will arise when the vibrations are doubled, or tripled, or quadrupled in frequency; but other ideas will be engendered by vibrations of an intermediate rate. Yet what these ideas will be may be predicted. It is true that this is only an optical case, but it extends the view that has been offered to us by a study of the structure of the ear. In the labyrinthine compartment of that organ the ultimate fibres of the auditory nerve are laid on the winding plane of the spiral lamina, in ever-decreasing lengths, each capable of trembling to the sound which is in unison with it—a mechanical action truly, answering to the sympathetic vibration with which the strings of a piano will respond to the corresponding notes of a flute—and these are translated by the mind into all the utterances of articulate speech, all the harmonies of music—speech that engenders new ideas within us, strains which, though they may die away in the air, live forever in the memory. The exquisite delight we experience in listening to the works of our great composers arises thus in mechanical movements, which are the issue of mathematical combinations. The unseen world is under the influence of number!

But what is number except there be one who numbers? When Pompey, in his Syrian war, broke into the holy of holies at Jerusalem, he expressed, as Tacitus tells us, his astonishment that there was no image of a divinity within; the shrine was silent and empty. And so, though after death we may anatomize and explore the inmost recesses of the brain, the veiled Genius that once presided there has eluded us, and has not left so much as a phantom-trace, a shadow of himself.

The experiments of Galvani and Volta have not yet reached their conclusion; those of Faraday and Du Bois-Reymond have only yielded a preliminary suggestion as to the nervous force. Excepting the great sympathetic nerve, the nervous fibres themselves are, as is well known, of two classes—those that gather the impressions of external things and convey them to the nerve-centres, and those that transmit the dictates of the will from within outwardly. The capabilities of one of the former—the apparatus for sight—have been greatly improved by various optical contrivances, such as microscopes and telescopes, an earnest of what may hereafter be done as respects the four other special organs of sense; and, as concerns the second class, the result of mental operations, the resolves of the will, may be transmitted with greater velocity than even in the living system itself, and that across vast terrestrial distances, or even beneath the sea. Telegraphic wires are, strictly speaking, continuations of the centrifugal nerves, and we are not without reason for believing that it is the same influence which is active in both cases.

In a scientific point of view, such improvements in the capabilities of the organs for receiving external impressions, such extensions to the distances to which the results of intellectual acts and the dictates of the will may be conveyed, constitute a true development, an evolution, none the less real though it may be of an artificial kind. If we reflect carefully on these things, bearing in mind what is now known of the course of development in the animal series, we shall not fail to remark what a singular interest gathers round these artificial developments—artificial they can scarcely be called, since they themselves have arisen interiorly. They are the result of intellectual acts. Man has been developing himself. He, so far as the earth is concerned, is becoming omnipresent. The electrical nerves of society are spread in a plexus all over Europe and America; their commissural strands run under the Atlantic and the Pacific.

In many of the addresses that have been made during the past summer, on the Centennial occasion, the shortcomings of the United

States in extending the boundaries of scientific knowledge, especially in the physical and chemical departments, have been set forth. "We must acknowledge with shame our inferiority to other people," says one. "We have done nothing," says another. Well, if all this be true, we ought perhaps to look to the condition of our colleges for an explanation. But we must not forget that many of these humiliating accusations are made by persons who are not of authority in the matter; who, because they are ignorant of what has been done, think that nothing has been done. They mistake what is merely a blank in their own information for a blank in reality. In their alacrity to depreciate the merit of their own country, a most unpatriotic alacrity, they would have us confess that for the last century we have been living on the reputation of Franklin and his thunder-rod.

Perhaps, then, we may without vanity recall some facts that may relieve us in a measure from the weight of this heavy accusation. We have sent out expeditions of exploration both to the Arctic and Antarctic seas. We have submitted our own coast to an hydrographic and geodesic survey, not excelled in exactness and extent by any similar works elsewhere. In the accomplishment of this we have been compelled to solve many physical problems of the greatest delicacy and highest importance, and we have done it successfully. The measuring-rods with which the three great base-lines of Maine, Long Island, Georgia, were determined, and their beautiful mechanical appliances, have exacted the publicly-expressed admiration of some of the greatest European philosophers, and the conduct of that survey their unstinted applause. We have instituted geological surveys of many of our States and much of our Territories, and have been rewarded not merely by manifold local benefits, but also by the higher honor of extending very greatly the boundaries of that noble science. At an enormous annual cost we have maintained a meteorological signal system, which I think is not equaled and certainly is not surpassed in the world. Should it be said that selfish interests have been mixed up with some of these undertakings, we may demand whether there was any selfishness in the survey of the Dead Sea? Was there any selfishness in that mission which a citizen of New York sent to equatorial Africa for the finding and relief of Livingstone, any in the astronomical expedition to South America, any in that to the valley of the Amazon? Was there any in the sending out of parties for the observation of the total eclipses of the sun? It was by American astronomers that the true character of his corona was first determined. Was there any in the seven expeditions that were dispatched for observing the transit of Venus? Was it not here that the bi-partition of Bela's comet was first detected, here that the eighth satellite of Saturn was discovered, here that the dusky ring of that planet, which had escaped the penetrating eye of Herschel and all the great European astronomers, was first seen? Was it not by an American telescope that the companion of Sirius, the brightest star in the heavens, was revealed, and the mathematical prediction of the cause of his perturbations verified? Was it not by a Yale College professor that the showers of shooting-stars were first scientifically discussed, on the occasion of the grand American display of that meteoric phenomenon in 1833? Did we not join in the investigations respecting terrestrial magnetism instituted by European governments at the suggestion of Humboldt, and contribute our quota to the results obtained? Did not the Congress of the United States vote a money-grant to carry into effect the invention of the electric telegraph? Does not the published flora of the United States show that something has been done in botany? Have not very important investigations been made here on the induction of magnetism in iron, the effect of magnetic currents on one another, the translation of quantity into intensity, and the converse? Was it not here that the radiations of incandescence were first investigated, the connection of increasing temperature with increasing refrangibility shown, the distribution of light, heat, and chemical activity in the solar spectrum ascertained, and some of the fundamental facts in spectrum analysis developed long before general attention was given to that subject in Europe? Here the first photograph of the moon was taken, here the first of the diffraction spectrums was produced, here the first portraits of the human face were made—an experiment that has given rise to an important industrial art!

Of our own special science, chemistry, it may truly be affirmed that nowhere are its most advanced ideas, its new conceptions, better understood or more eagerly received. But how useless would it be for me to attempt a description in these few moments of what Prof. Silliman, in the work to which I have already referred, found that he could not include on more than 100 closely-printed pages, though he proposed merely to give the names of American chemists and the titles of their works! It would be equally useless and indeed an invidious task to offer a selection; but this may be said, that among the more prominent memoirs there are many not inferior to the foremost that the chemical literature of Europe can present. How unsatisfactory, then, is this brief statement I have made of what might be justly claimed for American science! Had it been ten times as long, and far more forcibly offered, it would still have fallen short of completeness. I still should have been open to the accusation of not having done justice to the subject.

Have those who gloat over the shortcomings of American science ever examined the Coast Survey reports, those of the Naval Observatory, the Smithsonian contributions, those of the American Association for the Advancement of Science, the proceedings of the American Academy of Arts and Science, those of the American Philosophical Society, the Lyceum of Natural History, and our leading scientific periodicals? Have they ever looked at the numerous reports published by the authority of Congress on geographical, geological, engineering, and other subjects—reports often in imposing quartos magnificently illustrated.

Not without interest may we explore the origin of the depreciation of which we thus complain. In other countries it is commonly the case that each claims for itself all that it can, and often more than is its due. Each labors to bring its conspicuous men and its public acts into the most favorable point of view; each goes upon the maxim that a man is usually valued at the value he puts upon himself. But how is it with us? Can any impartial person read without pain the characters we so often attribute to our most illustrious citizens in political and, what is worse, in social life? Can we complain if strangers accept us at our own depreciation, whether of men or things?

We need not go far to detect the origin of all this—it is in our political condition. Here wealth, power, preferment—preferment even to the highest position of the nation—are seemingly within the reach of all, and in the internecine struggle that takes place every man is occupied in pushing some other man into the background.

I fear that in political life there is no remedy for this, such is the violence of the competition, so great are the prizes at stake. But in the less turbulent domain of science and letters we may hope for better things. And those who make it their practice to decry the contributions of their own country to the stock of knowledge may perhaps stand rebuked by the expressions that sometimes fall from her generous rivals. How can they read without blushing at their own conduct such declarations as that recently uttered by the great organ of English opinion, the foremost of English journals? The *Times*, which no one will accuse of partiality in this instance, says: "In the natural distribution of subjects, the history of enterprise, discovery, and conquest, and the growth of republics, fell to America, and she has dealt nobly with them. In the wider and multifarious provinces of art and science she runs neck and neck with the mother-country, and is never left behind!"

There are among us some persons who depreciate science merely through illiterate arrogance; there are some who, incited by superficiality, dislike it; there are some who regard it with an evil eye, because they think it is undermining the placid tranquillity they find in life-long cherished opinions. There are some who hate it because they fear it, and many because they find that it is in conflict with their interests.

But let us who are the servants of Science, who have dedicated ourselves to her, take courage. Day by day the number of those who hold her in disfavor is diminishing. We can disregard their misrepresentations and maledictions. Mankind has made the great discovery that she is the long-hoped-for civilizing agent of the world. Let us continue our labor unobtrusively, conscious of the integrity of our motives, conscious of the portentous change which is taking place in the thought of the world, conscious of the irresistible power which is behind us! Let us not return railing for railing, but, above all, let us deliver unflinchingly to others the truths that Nature has delivered to us!

The book of Nature! shall not we chemists, and all our brother-students, whether they be naturalists, astronomers, mathematicians, geologists, shall we not all humbly and earnestly read it? Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth! No man can tamper with it, no man can interpolate or falsify it for his own ends. She does not command us what to do, nor order us what to think. She only invites us to look around. For those who reject her she has in reserve no revenges, no social ostracism, no *index expurgatorius*, no *auto-da-fé!* To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine on which Truth sits enthroned, "dark with the excess of light!" Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that, whatever their dissensions of opinion may heretofore have been, in her presence they will find intellectual concord and unity.

MENTAL OVERWORK.

By ROBERT FARQUHARSON, M.D.

TO hit off the happy medium between over- and under-work is no easy task even to those who have the necessary knowledge, on the one hand, and the liberty to arrange their own scheme of occupation, on the other. But, for one person who is injured by doing too much, I quite believe with Dr. Wilkes that many may be found who are sustaining serious damage from not having enough mental stimulus. The listless vacuity in which so many of the well-to-do classes spend their lives, the want of any incentive to exertion, and the absence of any attempt at real thought which the wide-spread prevalence of ready-made opinions in our periodical literature directly encourages, must cause more or less degeneration of intellectual power. Under these conditions the brain gradually loses its healthy tone, and, although quite equal to the daily calls of a routine and uneventful existence, it is unable to withstand the strain of special sudden emergency, and, when a heavy load of work is unexpectedly thrown upon it in its unprepared state, then we see all the worst consequences of what may be called overwork develop themselves. It is no uncommon experience to meet with cases in which damage has been done to the bodily constitution by indulging too recklessly in athletic exercises and active physical exertion when the muscles have become flabby and feeble from disuse. A man accustomed to sedentary pursuits takes suddenly to boating or running, or the horizontal bar, and, if he escapes straining his heart, he is certain to make himself stiff and uncomfortable. Or he has been told that there is nothing like Switzerland for reviving the faded Londoner, so, without the slightest attempt at preparation, he dovotes himself enthusiastically to climbing ice-peaks and traversing snow-passes; and, when his brief holiday is over, he comes back, worn and jaded, and astonished to find that the glacial air, which has proved so beneficial to many, has done nothing for him.

Now, the fault here lies in the want of proper preliminary training. Even as we do not prescribe quinine as a tonic until we have ascertained that the digestive functions of our patient are in good working order, so it is most improper for any one to attempt active muscular exertion without bracing up the previously-unused muscles by carefully-graduated exercise. And in mental operations the same analogy holds good. If the brain is not habituated to the constant gymnastic influence of steady work, it is liable to give way or suffer more or less injury from any sudden and spasmodic effort. If, on the other hand, however, its healthy nutrition is insured by the free supply of pure blood and the true balance between destruction and repair, we shall find ourselves in possession of an organ which will bear almost any amount of steady strain, so long as certain conditions are fulfilled. So long as a brain-worker is able to sleep well, to eat well, and to take a fair proportion of out-door exercise, it may safely be said that it is not necessary to impose any special limits on the actual number of hours which he devotes to his labors. But when what is generally known as worry steps in to complicate matters, when cares connected with family arrangements, or with those numerous personal details which we can seldom escape, intervene, or when the daily occupation of life is in itself a fertile source of anxiety, then we find one or other of these three safeguards broken down. Probably the man of business or the successful advocate cannot shake himself free from his business thoughts at night. Slumber becomes fitful and disturbed. The sympathetic system, unsettled by the mental strain, brings about various defects in nutrition; the appetite fails, and the vigor of the nervous tissues is no longer able to withstand the endless round; and then we meet with the sleeplessness, the dyspepsia, the irresolution, the irritability, and the depression, which are among the chief miseries of those who we are in the habit of saying are overworked.

Now, the *Lancet* has lately laid before its readers some interesting statements which would lead us to believe that damage is being done to many boys in preparatory schools by the strong competition imposed upon them by the entrance-examination to the larger institutions, and by the ambition of their masters, who hope to derive profit and honor from their success. This is indeed a serious consideration, and the possibility of a large section of our most promising lads being thus mentally stunted in early life would demand instant interference did we deem the charge fully proved. Now, with all deference, I would venture to express my opinion, based on some experience, that, although we must not neglect so timely a warning of probable rocks ahead, there is no specific evidence of present injury. During my residence at Rugby I was in medical charge of several preparatory schools where the educational standard was very high, and where the success was proportionate when the boys came to be drafted off into the big school. I may truly say that no case was brought under my notice during the space of three years which I could in any way trace to overwork. And this I attribute to the perfect manner in which the counterbalancing conditions of health were sustained, the good food, satisfactory hygienic conditions, ample time for recreation and active sports, and frequent holidays. Boys of that age do not fret or worry over their work—they throw it off in their intervals of repose, sleep well, eat well, play well, and so do not suffer. Depend upon it, it would be little to the credit of any proprietor of a private educational establishment were he to neglect the laws of health, and send his boys home enfeebled and worn out from too heavy mental strain.

As regards the larger public schools the same remarks apply, and I met with very few instances at Rugby of any bad consequences from overwork; and in the three or four well-marked cases which came under my care I was enabled to detect some other equally operative cause which predisposed to the seizure. Thus one lad, ambitious of distinction both at classics and foot-ball, had undergone violent physical exertion while exhausted by study, and the supply of nerve-force, not being available for this double strain, gave way, and a sharp, feverish attack ushered in long-continued mental prostration. A second boy, who suffered from a precisely similar attack, had been sitting up late at night, and felt some anxiety about a future prize; and the third lad, who completes the catalogue, had also consumed the midnight oil to an undue extent. But, as a general rule, the typically healthy life and surroundings of our great public schools enable their inmates to withstand a much greater amount of work than lads brought up at home, who are often unduly spurred on, and who have not the healthful stimulus of enforced active exercise. Among this class I have seen a much greater proportionate extent of temporary break-down from the effects of mental exertion too long sustained and too little relieved.

Although the standard of the School Board is not very high, we may foresee a possible source of danger in forcing the minds of wretchedly feeble, ill-fed, and ill-housed children suddenly into educational grooves. I think I have seen an increase of headaches and nervous complaints among the children of the poor since compulsory attendance has been enforced, and would only wish to record the warning against attempts to make bricks too rapidly out of the straw which has fallen into our hands to mould for good or evil.

Coming to the universities, cases of overwork are, I imagine, more common there, for not only are the young men at a more sensitive period of life, but they naturally feel that to many of them this is their great opportunity—the great crisis of their existence—and that their success or failure will now effectually make or mar their career. Here the element of anxiety comes into play, sleep is disturbed, exercise neglected, digestion suffers, and the inevitable result follows, of total collapse, from which recovery is slow, and perhaps never complete. Others, again, endeavor in their last year to make up for the frivolities of the first two; but when Dr. Morgan takes up for us the history of the intellectual life of the universities in the same exhaustive way in which he has traced the statistics of their leading oars, I doubt not that we shall find that the indictment of overwork brought against them has also been much exaggerated.

But, although less common than is generally supposed, instances of this class of break-down do occur from time to time, and I should like to ask those who have devoted special attention to nervous diseases what is their view of the pathology of such cases as the following:

A student, or an artist, or the master of a public school, after a very heavy mental strain, suddenly gives way, and is seized with sharp illness, comparable in some degree to the old-fashioned brain-fever. On his recovery he takes a prolonged rest, and his general health is perfectly restored; he looks strong and hearty, and has even gained flesh, and so at last he thinks himself well enough to resume his duties. But it is found that, although he can do a little, anything like his old power of concentrated attention and steady application is gone, and if he tries to do a full day's work, he breaks down again in minor degree, and at last is obliged to content himself with taking only a very slight share in those occupations in which he used specially to excel, and in many cases his powers are never fully regained. With all the outward appearances of health, he well knows the very narrow limits within which he is now compelled to restrict his intellectual exercise. What, then, is the precise pathological condition here? Various diseases are also known to weaken the mental powers for long periods after convalescence is established, and of these scarlet and enteric fevers rank among the principal.—*Lancet.*

THE MEDICAL PROFESSION IN MODERN THOUGHT.[1]

By HENRY MAUDSLEY, M. D.,
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GENTLEMEN: It has devolved upon me this year to deliver, in accordance with prescribed custom, the introductory lecture to the course of systematic instruction upon which you are about to enter. At the outset I am free to confess that I have been not a little perplexed and troubled about what I ought most fitly to say; like many of my predecessors in the office, I have found the choice of subject beset with difficulties, and I have small hope that I can say anything to redeem the usual barrenness of the occasion. It is just twenty-five years since I, sitting where one of you now sits, listened to my first introductory lecture from the lips—mute, alas! now forever—of one whose pure and gentle nature attracted in no common measure the esteem, the respect, and the affection, of all who knew him. I mean the late Dr. Parkes. It is an extraordinary, almost an unparalleled, thing to say of any man, that no one who heard mention made of his name ever heard an ill word said of him; but I believe that this was strictly true of Parkes. His life, lovely and of good report throughout, was indeed a practical refutation of the saying, "Woe unto you when all men shall speak well of you." If I could sketch in striking outline the features of his character, and set forth justly the pure course of his life—showing with what patient industry and entire sincerity of insight he worked in scientific inquiries, how upright he was in all his ways, and how kindly considerate to others: how he lived, and how, his work faithfully done, he died—I should probably give you an inspiring and most useful introductory lecture; for I should present to you a noble example, the labor to imitate which would be an excellent scientific and moral training. But that has been done with more or less completeness by various persons, though not always, perhaps, with the discrimination which one would wish to see shown in the appreciation of such a character. It is a very amiable wish to say everything good of a man when he is silent forever, and the vocabulary of flattering words is apt to be exhausted in the endeavor to gratify this feeling, the effect sometimes being that the actual features of the character are blurred, and something which is intended to be very perfect, but which is very unreal, is produced. It seems to me that the distinguishing characteristic of Parkes, that by which mainly he was what he was, was not so much originality or height of intellect (in this others have equaled or surpassed him) as the height of his moral stature—in this perhaps he has hardly ever been surpassed; and that the grand lesson to be learned from the extraordinary esteem and affection which he inspired, from the infection of earnestness and sincerity which spread from him, and from the elevating influence which he exerted upon those who were brought into close converse with him, is a lesson which the history of human progress through the ages teaches too, and which needs much to be had in remembrance in these days of the glorification of science. It is this: that great as is knowledge, the moral nature is greater still; that the impulses of evolution which move the world come not from the intellect, but from the heart; that he who would work upon the hearts of others must speak to them from the heart; that everywhere and always we have to recognize the predominance of the heart over the intellect.

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[1] Introductory lecture delivered at University College, London, October 2, 1876.

Perhaps if I could recall vividly the thoughts and feelings of my mind when sitting there twenty-five years ago, and compare, or rather contrast, them with my thoughts and feelings now, I might extract from the comparison the essence of a quarter of a century's experience of life, and impart to you what it will probably take you a quarter of a century to acquire. But I am doubtful whether that would not be to do you a great disservice, for I could hardly fail thereby to take much heart out of your hopes, much ardor out of your enthusiasm, much energy out of your exertions. Moreover, I feel pretty sure that what I could say, however wisely it might be said, would not be of the least use to you. Neither nations nor individuals profit much by the experience of other nations or of other individuals; they must go through their experience for themselves, learning through suffering, succeeding through blundering, attaining to the calmness of wisdom through the fevers of passion; and many times only when opportunities are gone, and their consequences in irrevocable operation, is it seen perhaps how much better use might have been made of them. No doubt there is wise purpose in this inability of the young to take home and assimilate the experience of those who are older; for I know not how they could preserve that enthusiasm and freshness of spirit which make life itself a joy, and beguile them to pursue with eagerness its aims, were their illusions destroyed, as illusions one after another are destroyed by experience. In the full stream of its young energy life is too little conscious for reflection; to live is happiness enough; in its later stages more and more, as the heart is applied to know wisdom, is it felt to be vanity and vexation of spirit. This may seem a hard doctrine, but it is true; it has been the experience of the greatest sages of all times; it is the central thought of the great religious systems of the world.

Let me pass, however, from reflections which, if pursued, might tend to dishearten rather than to hearten you, and endeavor to show you that, as things go, you have made a good choice of a profession for your life's work. I should be thought to have ill discharged the function of introductory lecturer by preaching a gospel of pessimism, and inoculating you at the outset of your career with a despair of the littleness of life. Whatever the motive which has made you choose the medical profession as your life-career—and I suppose this has in most cases been the advice or example of others, or perhaps some quite accidental influence; for it is a startling consideration on what little circumstances the great issues of life often turn—you will not, I think, ever have cause to regret your choice if you look to the higher aim of it, and to that which is the proper end of human life. But on that condition only. It is not a profession which one who is ambitious of worldly distinction, or eager to accumulate much riches, should choose. You might, with prudence and industry, get vastly richer on the Stock Exchange or in commerce in a short time than you will probably after the labor of a long life in medical practice; and if you would aspire to gain a peerage or other ornamental thing of that kind, you would have done better to have gone into the army, and to have set before you as an aim, not the saving but the destruction of life; or to the bar, and have sold the highest exertions of your intellect to advocate the cause, whether the cause of the oppressor or of the oppressed, for which you were retained. Peerages don't come our way, and I am heartily glad they do not, for I much fear that there would not be the strength of mind to reject them; that a pitiful social ambition might tempt us to spoil the simple intrinsic nobility of our vocation with the outworn decorations of a childish stage of human progress. If medical practice be pursued as a mere means of money-getting, assuredly it causes the deepest demoralization of him who so uses it, as best things turned to basest ends breed the greatest corruption. He who deliberately applies himself to take the utmost advantage of the suffering and the feebleness of humanity, coming to him for aid in its anguish and its utter helplessness, in order to make his profit—and we may hope there are not many creatures of that vileness in the profession—may have large success in his low aim, but he discovers a meanness and a degradation of nature which are a grievous shame to his kind, and which devils might almost disdain.

But if you look to what is the true end of knowledge and work—to relieve the suffering and to minister to the comfort of man's estate, to lessen the sum of human sorrow on earth—you have chosen a profession which yields the fullest satisfaction to your aim and the largest scope to your work. We learn in order to act, the end of all knowledge being action; and the end of all action is to promote the welfare and the progress of mankind upon earth. In no profession are the opportunities of doing this good work so great and constant as in ours; to the least of us, as to the greatest, occasions of tender sympathy and patient help occur every hour in the daily routine of our work; and no profession, therefore, rests so little for appreciation upon any adventitious circumstance of time or place, or so little needs extraneous titles of honor to give it dignity and respect. Put a doctor in the midst of the wildest savages, and they will respect the "medicine-man," when the lawyer's fluent sophistry and the preacher's pathetic eloquence would not gain them consideration, or even save them from death. Livingstone passed unharmed and esteemed among the savage tribes of Africa under the protection of his medical skill; and Christ himself cultivated the character and functions of a healer of disease, not only because in that capacity he went about doing good, but probably also, as De Quincey surmised, for the secret reason that he thus disarmed the jealousy and suspicion which the ruling authorities might otherwise have felt of the crowds which he drew about him. When the mighty fabric of the Roman Empire, penetrated by internal decay, at last fell to pieces under the successive assaults of the Goths, and the Vandals, and the Huns, many thousand persons were, as Gibbon tells us, taken captive and distributed through the deserts of Scythia; and it is interesting to note what was the relative value of persons under these circumstances. "The skill of an eminent lawyer would excite only their contempt or their abhorrence. The vain sophist or grave philosopher who had enjoyed the flattering applause of the schools was mortified to find that his robust servant was a captive of more value and importance than himself. But the merit of the physician was received with universal favor and respect; the barbarians who despised death might be apprehensive of disease." So long as man deems it the most important thing in the world to him that he should go on living—and he does that commonly as long as he is alive—so long will he hold in favor and esteem him whom he believes able to prevent or to mitigate the suffering of disease, and to keep at bay "the last enemy," death. It has always been so. "Honor a physician with the honor due unto him for the uses which ye may have of him; for the Lord hath created him."

Having seen how good a thing is the direct work of relieving suffering by medical art, let me now go on to point out that the training through which you go in order to fit yourselves to do this is excellently well adapted to make the most of your intellect as an instrument of knowledge. It seems to me that no education which is given anywhere, taking it all in all, is better than that through which it is necessary to go in order to become a thoroughly accomplished physician. You are brought into direct contact with the facts of Nature, face to face with them from the beginning of your course; step by step you advance in the practice of observation and reflection, from more simple to more complex phenomena, and so you learn to make the order of your ideas conform gradually to the order of Nature. That is real instruction; moreover, it is instruction at first hand. In intercourse with Nature, sophistry and pretense avail nothing; sincerity, and humility, and veracity of mind, are essential; we must learn patiently her laws, and, learning, obey them, or we ourselves, our contemporaries, or our posterity, will suffer infallibly from their violation. There is no possibility of hoodwinking those eternal laws which, in our dealings with them, never make a mistake and never overlook one, never forego an advantage, never shrink to exact retribution, never feel remorse. When a person leaves college with a very respectable knowledge of Greek and Latin authors, and with little or nothing more than that, it seems preposterous that he should think himself an educated person. If he has learned nothing about the stars above his head and the earth beneath his feet; nothing about the nature of the air which he breathes, of the water which he drinks, of the food which he eats; cannot tell why water rises in a pump, or how a man breathes, and why he dies if he cannot get air to breathe; knows nothing whatever of the laws of the world in which he lives and of which he is a part, he is surely a profound ignoramus, notwithstanding that he may be able to make indifferent Greek or Latin verses. I would not for a moment undervalue the priceless benefits of a knowledge of Greek and Latin authors; on the contrary, I am sure that a study of the works of these great minds of antiquity, full as they are of the rich stores of human observation and thought, expressed in the most chaste, concise, and finished language, produces a discipline of intellect and a refinement of culture which can be got in no other way, and the loss of which in youth nothing gained afterward will ever entirely compensate for; but I am sure also that if Plato or Aristotle, or any of those great thinkers of antiquity, were to live again now, he would look with amazement and compassion, if not with contempt, on men who are content that education should consist in studying only the writings of the past, in utter neglect of the wonderful works of Nature to which the later ages of mankind have gained access, and of the vast stores of knowledge which have been gradually accumulated by the patient labors of successive generations of men. He would be apt, I think, to say something of this sort: "Good Heavens! we lived more than two thousand years ago; have you in all that time gained no new experience of men and things which it would be well to make an essential part of the intellectual culture of your children? is it education enough for life now to let them learn from us what we thought of men and things more than two thousand years ago, and to train them in a study of the structure of our dead language?" To state the matter so, sufficeth to expose its absurdity.

Now, the training of a medical man, when thorough, is admirable in this respect, that it follows the order of Nature, beginning with the less complex and rising to the more complex sciences, using the lower as a ladder by which to mount up to the higher. Coming to his work, as he certainly should do, with a fair knowledge of mathematics and physics, he proceeds to the study of chemistry, and passes on thence to the study of physiology; so he lays deep and firm the scientific groundwork for the study of the disorders of the structure and functions of the body, which is to be his ultimate special work. Without the foundations of the prerequisite studies he will not be a thoroughly well-grounded and cultivated physician, who may be relied upon to perfect his knowledge by experience through life, although he may no doubt be a fair practitioner in the routine which he has been taught, or, if he devotes himself to surgery, skillful as a mere operator. A knowledge of the simpler and more general science is an essential prerequisite to the study of the more complex and special science. Physics lie beneath chemistry; in physics and in chemistry we search for those intimate operations of matter which lie at the foundation of physiology; and physiology in its turn is essential to the construction of the more complex science which is concerned with man in his social relations—that is, sociology. And I may observe, by-the-way, that psychology, which is an important study for the man who has to put right the disorders of the minds and bodies of his kind, demands not only a thorough knowledge of physiology, but observation, also, of man in his social relations. Each science rests upon the one below it, but reflecting the increasing complexity of Nature as we rise from the movements of masses to the movements of molecules of matter, and to the combinations and relations of atoms, from dead again to living matter, from the simplest forms of life to complex organisms, and from organisms to the social union of organisms, contains in ascending scale something more than the science below it—something which constitutes its autonomy as a science. Physiology being placed in this scale, as you perceive, between chemistry and sociology, is on that account a most instructive study at the present time, when chemistry has made great progress toward scientific exactitude, and when the cultivation of the new field of social science is just being entered upon; there is no science, in fact, which yields such rich promise of large discoveries in the immediate future, and no science the discoveries of which, when applied to human needs, will do so much to lessen physical suffering. Fortunate are you, then, in the training which prepares you for the study, and in the lot which at this particular era has fixed your work in the pursuit, of a science which promises so great an abundance of good fruit.

One warning I would stop a moment here to urge. While recognizing the subordination of the sciences, we ought not to overlook the fact that all the sciences are at bottom artificial divisions; that the world is not divided rigorously into those different domains which we call physics, chemistry, physiology, and the like; that we make the divisions for our convenience according to the complexity of the phenomena, not because we discover them in Nature. Nature is one and continuous, and takes not the least notice of the arbitrary divisions which we find it necessary to make. It would seem a very obvious distinction between plant and animal; and yet if we push our investigations into that border-territory of Nature where animal and vegetable life touch, we meet with so-called monads—the *Heteromita*, for example—which may be referred with equal justice to either kingdom; there are organisms which we think vegetable, having characters which we call animal, and organisms which we call animal, having characters which we think vegetable; there is, in truth, no line of demarkation, but instead an insensible series of gradations, and no man can say where the one kingdom ends and the other begins. In like manner, notwithstanding the seemingly gross and palpable distinction between living and dead matter, any one who sets himself to work to find out where life begins will be hard put to it to draw a line of separation, and more hard put to it when called upon to make good his division. Man himself, much as he makes of himself, is not separated from the rest of Nature by an impassable gulf; he modifies Nature largely, it is true, but the art by which he does that is Nature; he is a part of the order thereof—the latest product of the evolution which went on for countless ages before he appeared upon earth, which is going on now in his progress, his knowledge and his moral feelings being agencies in the process, and which, for anything we know, will go on for countless ages after the earth, which he has ceased to replenish and subdue, has fallen into the condition in which the moon now is, and rolls on its solitary way through space, a cold and desert globe, the tomb of all human aspirations, sorrows, sins, and achievements. In making use, then, of the arbitrary divisions of our sciences, we ought never to lose hold of the actual unity and continuity of Nature; never to overlook the fact that there is not a single truth in any science which has not its essential relations with the truths of all sciences; never to forget that the least things and the greatest are indissolubly bound together as equally essential elements of the intimately connected and mysterious whole which we call the universe. It may seem a fanciful saying, but there is a truth in it, that you cannot utter an exclamation, strike a note on a piano, move a grain of sand from its place, without affecting the entire universe.

Now the systematic training of the mind in conformity with the order of Nature, through patient observation and careful induction, the knowledge of Nature which is got by becoming, as Bacon says, her servant and interpreter, is a tedious business. Men, therefore, have gladly shirked it; they have found it much easier to attribute phenomena to some metaphysical entity which they have created out of a mental abstraction, or to invoke a supernatural cause to account for them, than to find out the explanation. In consequence of this habit of mind, which has had large operation in the past, a body of doctrine has grown up which, having had its day, is now fast becoming effete, but which men will not willingly part with—doctrine comparable, if I may use a physiological comparison, with those organs which, like the thymus gland, have their uses at a certain stage of the body's development, but afterward, having no longer any function, undergo atrophy. Moreover, men have not only shirked positive inquiry from indolence, but have hated it from hostility. They dread the thought of being shown to be one with Nature, and repudiate with abhorrence the suggestion that their bodies and minds will ever receive scientific explanation; as if their bodies and minds would be degraded to something quite different from what they are by being understood like other natural phenomena and described in terms of scientific thought. The supposition strikes them as something like a blasphemy against the nobility of their nature. Hence there is a deep-rooted instinctive hostility to the science that has to do with man, which you will have to take account of in your careers—an hostility which has found partial expression, I think, in the anti-vivisection agitation. There was more in the fierceness of that agitation than a laudable feeling of compassion for the animals—an intensity of acridity betraying another origin. There was the energy of fear and hatred—fear and hatred of the science which threatens the dethronement of man from the pedestal of conceit upon which he has placed himself, and the destruction of some of his traditional beliefs. But a little reflection might serve to prove to those who are moved by these hostile apprehensions that they are possessed with an unreasoning fear, and are disquieting themselves in vain. Let them look beyond the dark circle of their self-love, and they will see that what is good in old creeds does not perish; that, although old forms vanish, as generations and nations pass away, that in them which gave life to them does not pass away, but puts on new forms and survives, as new generations and nations follow and carry onward the work of progress. Better would it be for them to seek for and foster the good which survives than to lament and defend the old which is corrupt.

Certainly science has not been careful to avoid occasions of offense in its progress, and of its method and pretensions its votaries have sometimes written in a strain which justly provokes scorn. While proclaiming, then, the praises of observation and induction, and enforcing the value of a mental training which is obtained by studying Nature after that method, let me interpose a few words of qualification, in order that I may not be misunderstood. I cannot help feeling that a great deal of questionable doctrine has been propounded concerning the so-called method of induction which science is enjoined rigidly to pursue, and that Bacon would have been aghast had he seen the absurdity which some persons in these days describe as his method, and the imbecile procedures of some of those who believe that they are following it. They talk, in fact, of the method of observation and induction as if it were something to conjure by; a mechanical process of knowledge-getting which rendered superior mental capacity unnecessary; a sort of intellectual ladder by which the most stupid beings, if they only planted it properly, might mount up into the highest places of knowledge. That was not Bacon's notion of it: he perceived clearly enough that a man does not see with his eye, but through it; that seeing in the sense of observation is impossible unless there be behind the eye the intelligence to interpret what is presented to it. The simplest act of perception is indeed more than a mere matter of sense; it is an actual induction or inference in which an important element is contributed by the mind; you cannot look at an ox or an ass, and know either of them to be what it is, without making an induction—can't see, in fact, until you are trained to see. Scientific observation and experimentation—and experiment is only observation aided by artificial means—may be carried on to the last hour of your lives without any result of the least value if you have not a mind trained to interpret. Of what use is it to torture Nature by strange experiments if you don't understand her language? You might sacrifice a hundred dogs or cats in cruel experiments, and be not a whit wiser at the end of your awful labors. Nature does not vouchsafe an answer to a scientific inquiry unless the intelligent question be put, and the precise experiment made, as Bacon insisted, *ad intentionem ejus quod quæritur;*[1] and it is impossible to put the definite question, or to make the precise experiment, unless there be a prudently-formed hypothesis in the mind—that is to say, an hypothesis based upon previous careful training in observation of Nature's processes and sound reflection upon them. The mind must be informed by patient and sympathetic intercourse with Nature; it is enabled then to make new adjustments by means of the knowledge which it has gained through past adjustments—to frame a new and true theory applicable to new experiences by reason of being stored with sound theories derived from past experiences. We shall do well, then, not to be too much intimidated by what is sometimes said or written in praise of mere observation of so-called facts, and in dispraise of theory, or imagine that any facts can be truly observed, or any science prosecuted with success, unless the well-trained mind coöperates with the senses. As I have said elsewhere, "That some declaim so virulently against theory is as though the eunuch should declaim against lechery; it is the chastity of impotence." Happy is the observer who, when he sets to work, has a good theory in his mind. The mischief is when men theorize who have not been trained in habits of accurate observation, or, I might go a step further and say, who have not inherited from father or grandfather in the foundations of their nature the lines of veracity of observation and thought on which to develop; for when one notices how persons of a certain eager temperament go on discovering facts which are no facts, and, notwithstanding that they are brayed in the mortar of an annihilating criticism, are not in the least benefited by the discipline, one cannot help feeling that the observer, like the poet, is born, not made.

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[1] With special reference to the point under investigation.

But it is time to return to the direct line of my argument. From what has gone before, it should appear at what an excellent place of advantage the order of studies for the medical profession is adapted to place you; how wisely it is arranged to train the mind for sound reflection upon those most complex phenomena of Nature with which the medical man has to deal—the phenomena of life in health and in disease; and how sadly wrong in theory and mischievous in practice he is likely to be who neglects to lay well the foundations of his mental training. If no practical result were to follow a medical education, if it were not pursued, as it is, for the purposes of the medical art, I believe that one who aspired to fit himself best to understand the world in which he lives, and the men with whom he has to do, could not do better than go through it; for it would be an excellent foundation on which to build afterward. The study of man cannot be undertaken with any satisfaction, or carried out with any completeness, except through a previous study of the nature of which he is the present culmination; it is certainly not possible to enter the chamber of the mind without passing through the antechamber of the body; and we cannot understand the body unless we understand a good deal of the processes and laws of Nature which lie beneath biology. So far, then, Mr. Lowe appears to be right when he regrets, as he is in the habit of doing, that he was taught so much classical knowledge and no science when he was educated, and contrasts the disadvantages under which he labored with the advantages which each student at a middle-class school now enjoys. Newspaper critics think that he is making jokes or firing off paradoxes, and would seemingly rather have Mr. Lowe as he is than Mr. Lowe as he might or would have been; but I am disposed to think that Mr. Lowe's insight has enabled him to see what his critics quite fail to see—that the statesman who has to deal with the relations of men to one another in the world would be better qualified for his work if he had a good fundamental knowledge of the laws of man's nature and constitution, and of the laws of the world in which he lives. The scientific statesman—when we get him—will hardly deem it his highest achievement to shrink scared from the grasp of a principle, or his supreme privilege and merit to wait patiently to catch the fitful gusts of an ignorant public opinion.

The application of the principle which I have been enforcing, of learning to know man through Nature, the thorough knowledge of his environment, and of those of his relations to it which constitute his life, must clearly be the foundation of a scientific medicine. Here, as elsewhere, prevision for the purposes of action is our aim; we observe and infer in order to foresee, and, foreseeing, to modify and direct; we conquer by obeying, gaining a knowledge of the phenomena of living beings in order to make ourselves masters of them, just as by a knowledge of physics and chemistry we gain a mastery over the phenomena of physical Nature. It is impossible to treat a sick person, except in the most lamely empirical fashion, without a knowledge of the properties of the organism and of its relations to its environment; for our medical function is to remove the disorder of these relations, which is disease, and to restore the harmony, which is health. In past times it has been too much the practice to treat the body as if it were an entirely independent kingdom, without regard to its essential relations with surrounding Nature, and to try to drive out the enemy which was supposed to have taken possession of it, by pills and potions, as barbarous nations try to drive him out by charms and ceremonies. Now, however, in the recognition of the intimate and constant relations between the organism and its surroundings, we are awaking to juster views of our duties as observers, and of our work as curers of disease; but it is because of the absence yet of anything like exact knowledge in this respect that medical practice is defective, tentative, empirical, often mere guess-work, and that the most experienced physicians, waiting patiently on Nature, aim to do the least harm by the drugs which they employ.

But we are perceiving more clearly, day by day, a larger application of this principle of looking to the relations of man, to what is around him as well as to what is within him, in the fulfillment of the great purpose of preventing disease. It is in this direction that the future course of medicine lies clearly open, and to this end that we must work; it will rise to the true height of its great vocation when it watches over communities, and ministers to the welfare and development of the race. I am apt to think that we shall attain to earlier and larger success in preventing the diseases of communities than in curing the diseases of the individual, as men who had been seeing heavy bodies fall to the earth every moment of their lives discovered the law of gravitation for the first time when they began to observe the grand general motions of the heavenly bodies. Indeed, we have already had encouraging success. Look through the yearly death-list of this great city two hundred years ago, and you will find a large proportion of deaths ascribed to diseases which have now been robbed of their sting, if they are not quite extinct. Many persons died then, as "that chief of men," Cromwell, did, from ague. Where is the mortality of ague now? Ague has disappeared with the disappearance, through better drainage, of the damp fogs which occasioned it, as ghosts and other superstitions have vanished with the disappearance, before the light of knowledge, of the fogs of ignorance in which they were engendered. Bloody-flux or dysentery seldom occurs now in England, and is more seldom fatal, but it caused many deaths two hundred years ago. The ravages of small-pox were then terrible, hosts of victims being carried off by it, and many persons who escaped death bearing its marks in blind eyes and hideously-scarred features; but I think we may foresee a time when, Keighley guardians notwithstanding, small-pox will no more afflict a prudent people. Plague, scurvy, and spotted fever, each of which then claimed regularly its yearly tribute of victims, are becoming almost diseases of the past, and one needs not a prophet's imagination to foresee a time when cholera, scarlatina, fever, phthisis perhaps, and other diseases, will be no more; when preventive medicine shall have reached such a degree of perfection that the occurrence of epidemic disease will be felt as a gross reproach to the community, and when there will be comparatively little for the practitioner to do in the treatment of particular disease. It is unfortunate truly, as it is sadly unseasonable, that just when we see before us this fairer prospect, and when an encouraging beginning of progress has been made under the auspices of Mr. Simon and his well-organized staff, he should have been driven from office and his office abolished. But one instance more of the difficulties with which progress has to contend from the selfish intrigues and obstructive apathy of mankind!

You may be disposed perhaps to smile at my outlook as fancifully bright, and befitting only the imaginative flights of an introductory lecture. From the beginning, it may be said, men have, through unrestrained indulgence of their passions, generated disease, and however pure their surroundings may be made, they will go on doing the same thing: were a clean sweep made of all disease from the face of the earth to-morrow, they would breed it afresh before to-morrow's morrow. No doubt, as they are constituted and trained at present, they would be apt to do so; but one may hope that the medical science of the future—and here I would carry your imaginations a little way with me—will have a great deal to say in the way of instruction respecting the highest concerns of man's nature, and the conduct of his life; that it will enter a domain which has hitherto been given up exclusively to the moral philosopher and the preacher. I don't propose or suppose that we shall ask these gentlemen to step down from their platform, saying to them something of this kind: "You have been preaching wisdom and goodness of conduct for some thousands of years, and you haven't made much of it. Certainly one result thus far is striking enough: that men are devoting their eagerest energies to making the most destructive guns, and are conferring their greatest honors and applause on those who use them with the most destructive effects. For months, until quite lately, the soil of Eastern Europe was deluged with blood, shed amid unspeakable atrocities, in an entirely needless war, which your statesmen, presumably the highest products of the culture of your epoch, could or would do nothing to check. Stand aside, then, and let us try our method." To speak so would be as foolish as it would be arrogant; but we may perhaps, without undue presumption, promise them that, if they will learn and use the results of our method, they will have a deeper and more stable foundation in the constitution of human nature for their teaching than they have now, and will add much to the efficacy of it by enforcing motives which will touch more keenly the springs of human conduct than those which they present. Now let me indicate very briefly, as must needs be, the method by which medical science is to advance to take possession of this higher ground.

Starting with the trite maxim that before we can act we must learn, it is obvious that, before we can teach men to act with more wisdom than they have done in the past, we must give them a better knowledge of their own nature and relations than they have had. This we propose to do by the patient and steadfast application of the method of observation and induction, which has served us so well in the subordinate branches of science, to the highest phenomena of man's being—his thoughts, feelings, and conduct. The problem is the same here, in fact, as in the lower sciences—to observe in order to foresee, and to foresee in order to modify and direct; and the method is the same. Admitting, as I see not how we can help doing scientifically, that a process of evolution has gone on in Nature, and that man, as he now is, is a product of the past carrying on this process in his progress to a higher purpose in the future, it is a natural conclusion that he must, as a part of Nature, be studied by the same method as the rest of Nature. We have to search back and find out how he came to be what he is by looking to the historical evolution of the race from its earliest known conditions, and by tracing in the development of the organism the operation of laws which we discover at work under less complex conditions in the rest of Nature. When we do that, we find the best reason to believe that the highest faculties of his mind, his intellect, and his moral feelings, have not been implanted ready-made in his nature at any period of its history, but have been the slowly-won results of the accumulated experiences of the race transmitted by hereditary action: that is the lesson which observation and induction, applied to the investigation of the origin and development of man's higher nature, teach with an authority which cannot be gainsaid from any standpoint of positive knowledge. I could have wished, had I had time, to have shown you how some phenomena of mental disease, which may be looked upon in this relation as instructive experiments of Nature made for us in a domain where we cannot make them for ourselves, confirm the induction which has been reached by observation of human development, both in the individual and in the race. But I must leave that unsaid, and restrict myself to the conclusion as regards conduct which results from the acknowledgment that the latest and best acquisitions of man have come to him by a process of ordinary development through the ages. For the problem of to-day is truly no longer the schoolmen's much-vexed question of the origin of evil, but the question of the origin and growth of good. Our plain duty is to find out the laws which have been at work in that process, and to continue it—to carry on, by deliberate method, with conscious purpose, the development which has been going on through past ages irregularly and blindly. The time, in fact, has come when mankind should awake to the momentous reflection how great is the power which it may exert over its own destiny, and to the resolution methodically to use it. In fulfilling this paramount duty, upon whom will the function of inquiry and instruction immediately rest, but upon those who make the laws of vital development and function their study, and the application of the knowledge to further the well-being and development of the organism their work? Clearly, the medical investigator need not lapse into despair because he has no new conquests to make.

You will not be long in practice before you will have many occasions to take notice how little people ever think of the power which they have over their own destiny and over the destiny of those who spring from them—how amazingly reckless they show themselves in that respect. They have continually before their eyes the fact that by care and attention the most important modifications may be produced in the constitution and character of the animals over which they have dominion—that by selective breeding an animal may almost be transformed in the course of generations; they perceive the striking contrast between the low savage with whom they shrink almost from confessing kinship and the best specimens of civilized culture, and know well that such as he is now such were their ancestors at one time; they may easily, if they will, discover examples which show that by ill living peoples may degenerate until they revert to a degraded state of barbarism, disclosing their former greatness only in the magnitude of their moral ruins;—and yet, seeing these things, they never seriously take account of them, and apply to themselves the lessons which lie on the surface. They behave in relation to the occult laws which govern human evolution very much as primeval savages behaved in relation to the laws of physical Nature of which they were entirely ignorant—are content with superstitions where they should strive to get understanding, and put up prayers where they should exert intelligent will. They act altogether as if the responsibility for human progress upon earth belonged entirely to higher powers, and not at all to themselves. How much keener sense of responsibility and stronger sentiment of duty they would have if they only conceived vividly the eternity of action, good or ill; if they realized that under the reign of law on earth sin and error are inexorably avenged, as virtue is vindicated, in its consequences; if they could be brought to feel heartily that they are actually determining by their conduct in their generation what shall be predetermined in the constitution of the generation after them! For assuredly the circumstances of one generation make much of the fate of the next.

In the department of medical practice in which my work mainly lies I have this amazing recklessness strongly impressed upon me; for it occurs to me, from time to time, to be consulted about the propriety of marriage by persons who have themselves suffered from insanity, or whose families are strongly tainted with insanity. You will not be surprised to hear, I dare say, that I don't think any one who consults me under such circumstances ever takes my advice except when it happens to accord with his inclination. The anxious inquirer comes to get, if he can, the opinion which he wishes for, and, if he does not get that, he goes away sorrowful, and does just what his feelings prompt—that is, gets married when he has fallen in love, persuading himself that Nature will somehow make an exception to inexorable law in his favor, or that his love is sufficient justification of a union in scorn of consequences. Certainly, I have never met with so extreme a case as I chanced to light upon in a book a short time ago. "I actually know a man," says the author, "who is so deeply interested in the doctrine of crossing that every hour of his life is devoted to the improvement of a race of bantam fowls and curious pigeons, and who yet married a mad woman, whom he confines in a garret, and by whom he has insane progeny." But I have met with many instances which prove how little people are disposed to look beyond their immediate gratification in the matter. If it were put to two persons passionately in love with one another that they would have children, one of whom would certainly die prematurely of consumption, another become insane, and a third, perhaps, commit suicide, or end his days in workhouse or jail, I am afraid that in three cases out of four they would not practise self-denial and prevent so great calamities, but self-gratification, and vaguely trust "the universal plan will all protect!"

Those who pay no regard in marriage to the evils which they bring upon their children, or in their lives to the sins by which the curse of a bad inheritance is visited upon them, may plead in excuse or extenuation of themselves the vagueness and uncertainty of medical knowledge of the laws of hereditary action. We are unable to give them exact and positive information when they apply to us, and they naturally shelter themselves under the uncertainty. Were our knowledge exact, as we hope it will some day be, we could foretell the result with positive certainty in each case, and so speak with more weight of authority. It is one of the first and most pressing tasks of medical inquiry to search and find out the laws of heredity, mental and bodily, in health and in disease, and, having discovered exactly what they are, to apply the knowledge purposely to the improvement of the race—that is, to prevent its retrogression and to promote its progress through the ages. I see no reason to doubt that by discovery of these laws and intelligent practical use of our discoveries we might in the fullness of time produce, if not a higher species of beings than we are, a race of beings, at any rate, as superior to us as we are superior to our primeval ancestors; the imagination of men seems, indeed, in the gods which they have created for themselves, to have given form to a forefeeling of this higher development. But I will not pursue this pregnant matter further now; I have touched upon it only for the purpose of illustrating the large scope of the medical work of the future, which is to discover those laws which have been in operation through the past to make man the superior being which he is, and to determine his future action in intelligent conformity with them; not only to cure disease of body and mind, as it has aimed to do in the past, and to prevent disease, as its larger aim now is, but to carry on the development of his nature, moral, intellectual, and physical, to its highest reach.

So much, then, concerning the three topics on which I have proposed to myself to discourse in this lecture—namely, the nobility of your direct function as healers of disease, the excellence of the method of medical study as a means of intellectual and moral training, and its fruitfulness in benefits to mankind, and the grandeur and the reach of its aspirations for the future. Let me hope that I have, in fulfillment of my design, said enough to satisfy you that you have made a good choice of a profession for your life's work. Having chosen, it remains only that you should justify your choice by your work, so that it may be said of each of you, when his long day's task is over and the night has come, that he was in his right position in the world, and made a right good use of it. Life has its three stages—youth, manhood, and old age; let it be your anxious care now, in the first stage of joy and hope, so to pass the second stage of work and duty that the last stage may not be a long regret.

I will ask your indulgence only for a few minutes more, while I detain you for one or two final reflections of what I may call an inhibitory character. In pursuing resolutely the course of scientific inquiry which I have indicated, it must needs be that offenses sometimes occur, for we can hardly fail to come into collision with some of the prejudices and traditions of mankind. I do not know how it is possible, for instance, to prosecute the physiological investigation of mind to its farthest reach without shaking the foundations of the metaphysical notions which have been held concerning it and its functions; and with the fall of these notions, long cherished of mankind, other notions that are bound up with them may totter to their fall. But, if this must be, we shall do well to acknowledge it more in sorrow than in anger. Let us not rush with eager fury and exultant clamor to the work of destruction; it behooves us, as products of the past, who will one day ourselves constitute the past, to deal gently and even reverently with it. We cannot break with it if we would, nor should we if we could. The very language which we use we owe to the slow acquisitions of generations which have preceded us; we cannot compassionate or contemn them except in words for which we are indebted to them. There is hardly a word I have used in this lecture which, were its history searched out, does not mean generations of human culture to which we are heirs. Seems it not, then, a wicked, almost a sacrilegious, thing to hasten with eager gladness to repudiate the past to which we owe everything, and to exult over the ruins of its beliefs? It is as if a son should rejoice over his father's feebleness, uncover his nakedness, and make scorn of his infirmities. As he who has been the best son is in turn the best father, so the generation which guards with respect the good which there is in the past, and puts gently aside that which is effete, will make the most stable progress in its day, and transmit the best inheritance to the generation which follows it. No doubt in the future, as in the past, the knowledge of one period will sometimes appear foolishness at a more advanced period of human evolution—the truth of one age become the laughing-stock of the next; but we may profitably reflect that decaying doctrine had its use in its day, and it may teach us modesty to consider that much which has its place in our mental organization now, and is serving its proper end in the development thereof, will one day probably be put aside as obsolete belief. Let it be our prayer that when that day comes, and this generation comes up for critical judgment as an historical study before the tribunal of posterity, it may be justly said of it that it has done as much for the progress of mankind as some of the generations upon which the wisest of us look back, perhaps, with indulgent compassion, and the unwise among us with foolish scorn.

There is nothing in the attitude of modern society toward science, cold and suspicious as it may sometimes be, which necessitates or warrants an arrogant, defiant, and aggressive spirit of hostility on its side. No great courage is required nowadays to declare a new truth, however hostile it may be to received belief, nor is any serious suffering entailed by the declaration; there is no need, therefore, for a scientific man to put on the airs of a martyr. He is a very little martyr who is persecuted only by the pens of unfriendly critics, and rather a pitiful object when he sits down by the wayside, and calls upon all them that pass by to behold and see how hardly he is used. It was very different when Science first made its voice heard; when, under the cruel persecutions of the Inquisition, Galileo unsaid with his tongue truths which his heart could not unsay, and that grand figure in the noble army of scientific martyrs, Giordano Bruno, went calmly and resolutely to the stake rather than utter one word of retractation. The saddest contemplation in the world, perhaps, is that of the brave who, like him, have died fighting in the battle for the cause that seemed to perish with them; whose lives of suffering and sore travail have set, often through cruel tortures, in black clouds of gloom which no ray of hope could penetrate. Theirs was not the laurel crown of victory after the agony of the struggle; no popular applause, no encouraging shout, greeted their ears as they sank down exhausted in death; the shouts which they heard were shouts of execration, and their crown was the martyr's crown of thorns. We have, happily, fallen on better days; the secrets which we win from Nature we may proclaim without fear, and in the confident assurance that, after being proved and tried, they will be accepted; we are fighting a winning fight, and the stars in their courses are with us. What cause, then, for arrogant self-assertion, overbearing aggression, and willful determination to seek occasions of offense? The advantages of our position and strength entail the responsibility of moderation and forbearance, for the strength is not our own—it is the power of the universe working in us to its higher ends.

One may esteem science duly, then, without feeling sympathy with the aggressive delight with which some persons accentuate its hostility to expiring doctrines, and exult in the overthrow of articles of faith which have sustained and solaced multitudes of men in the dark hours of life and in the darker hour of death. It can be no pleasure to a generous nature, inevitable though it be, to shatter the faith of even the poor Indian, who, driven from his hunting-grounds by the inexorable fate of a stronger race, looks upward with feeble faith to a Great Spirit, and forward with dim hope to the happy hunting-grounds far away where the sun goes down. To aspire to be the first to proclaim the downfall of a position of refuge to which men have clung with passionate earnestness for many generations seems to show "a pitiful ambition in the fool who uses it," a singular blindness to the essential continuity of development, a strange ignorance of what is the final end of all science. A scientific discovery is a very good thing in its way, but it is only a means to an end, after all—the improvement of man's estate—that is to say, his moral and intellectual as well as his material state; and when he who has been happy enough to discover a new metal or a new star or a new cell or a new salt magnifies himself mightily, and fondly dreams of an immortal fame, one cannot help some such feeling of the ludicrous as would be raised by the spectacle of a hodman who, having carried his brick to the building in course of construction, should call upon all the world to take notice of the wonderful work which he had done in architecture. Science has yet to realize, at any rate its cultivators seem oftentimes to forget, that its end must be constructive; that after analysis must come synthesis; that all the analytical work in the world will leave matters in a chaotic state until the constructive spirit, moving over their surface, shall organize the incoherent results, and make them serve for a higher social development. The problem is to make straight in the future a highway over which mankind may pass to a higher life. The philosopher who, with far-reaching eye, overlooks the relations of sciences; the poet who reveals subtilties of human feeling, gives lofty utterance to human sympathies with Nature, and infuses nobler aspirations into men; the preacher of human brotherhood who, inspired with strong moral feeling, proclaims the lessons of selfrenunciation and of duty to neighbor—these are brighter stars in the firmament of human genius than the scientific discoverer. The discovery of the law of gravitation is the grandest attainment of scientific thought; but can we justly compare the effects of that generalization upon human interests and happiness with the elevating influence which is exerted by the poetry of Isaiah or of Shakespeare upon multitudes throughout the world; which is perhaps being felt at this very moment by fireside or on sick-bed in distant lands—by the solitary dweller on the skirts of the vast forests of Western America, in the great lone land of Canada, in the farthest depths of the Australian bush? Science has not rendered the philosopher, the poet, and the moral teacher superfluous, nor will it ever supersede them; on the contrary, it will have need of them to attain to its own perfect working to the bettering of man's estate; and it may well seem to some that the time has come when its manifold scattered and somewhat anarchical results should be penetrated by the synthetic insight of the philosopher, be embodied in forms of beauty by the poet's imagination, and utilized by the moral teacher to guide and promote the progress of mankind. So long as man sees splendor in the starry heavens, beauty in the aspects of Nature, grandeur and glory in self-sacrifice, so long will he feel that his brief conscious life is but a momentary wavelet on the vast ocean of the unconscious; that there is in him the yearning of something deeper than knowledge, which "cometh from afar," and which the labored acquisitions of science will ever fail to satisfy.

ABOUT SHARKS.

SHARKS are usually spoken of as the most rapacious and abhorrent of sea-animals. That they are rapacious is undeniable, but why they are so is not generally considered. We will go a little into the matter. The shark, a fish of the family *Squalidæ*, when quite in his infant state, and only a few inches in length, exhibits a pugnacity almost without parallel for his age. He will attack fish two or three times larger than himself; or, if caught, and placed for observation on the deck of a vessel, he resents handling, and, with unerring precision, strikes a finger placed on almost any part of his body.

Two things contribute to the shark's determinate fierceness. In the first place, we may refer to his teeth, for of these engines of destruction Nature has been to him particularly bountiful; and this species of bounty he has a peculiar pleasure in exercising. If he could speak, he would probably tell us that, besides being troubled with his teeth, which he could not help keeping in use, he had been gifted with enormous abdominal viscera, and that, more particularly, a third of his body is occupied by spleen and liver. The bile and other digestive juices which are secreted from such an immense apparatus, and poured continually into the stomach, tend to stimulate appetite prodigiously—and what hungry animal with good teeth was ever tender-hearted? In truth, a shark's appetite can never be appeased; for, in addition to this bilious diathesis, he is not a careful masticator, but, hastily bolting his food, produces thereby not only the moroseness of indigestion, but a whole host of parasites, which goad as well as irritate the intestines to that degree that the poor squalus is sometimes quite beside himself for the torment, and rushes, like a blind Polyphemus, through the waves in search of anything to cram down his maw that may allay such urgent distress. He does not seek to be cruel, but is cruelly famished. "It is not I," expostulates the man in the crowd, "that is pushing; it is others behind me." The poor wretch must satisfy, not only his own ravenous appetite, but the constant demand of these internal parasites, either with dead or living food; and therefore it is that, sped as from a catapult, he pounces on a quarry, and sometimes gorges himself beyond what he is able to contain.

Having said thus much of the rapacious habits of the *Squalidæ*, we would have it remembered that every man's hand is against them, and that no tortures are considered too severe to inflict upon them when caught. If they are relentless to man and every living thing around them, their insatiable appetite renders them equally destructive to their own species, and we of the white population of this globe ought to recollect, with some show of gratitude, that they always prefer an African to a European; for, although they are fond of men of any color, a negro is to them as the choicest venison. Commerson tells us that one of the atrocious amusements practised on board slave-ships was to suspend a dead negro from the bowsprit, in order to watch the efforts of the sharks to reach him, and this they would sometimes effect at a height of more than twenty feet above the level of the sea. Wonderful are the tales that sailors tell of the various things that have been found in a shark's stomach, and it was thought that any substance that would enter its mouth was at all times acceptable. The following, which details a cruel trick, as described in the *Glasgow Observer*, dispels this illusion: "Looking over the bulwarks of the schooner," writes a correspondent to this journal, "I saw one of these watchful monsters winding lazily backward and forward like a long meteor; sometimes rising till his nose disturbed the surface, and a gushing sound like a deep breath rose through the breakers; at others, resting motionless on the water, as if listening to our voices, and thirsting for our blood. As we were watching the motions of this monster, Bruce (a little lively negro, and my cook) suggested the possibility of destroying it. This was briefly to heat a fire-brick in the stove, wrap it up hastily in some old greasy cloths, as a sort of disguise, and then to heave it overboard. This was the work of a few minutes; and the effect was triumphant. The monster followed after the hissing prey. We saw it dart at the brick like a flash of lightning, and gorge it instanter. The shark rose to the surface almost immediately, and his uneasy motions soon betrayed the success of the manœuvre. His agonies became terrible; the waters appeared as if disturbed by a violent squall, and the spray was driven over the taffrail where we stood, while the gleaming body of the fish repeatedly burst through the dark waves, as if writhing with fierce and terrible convulsions. Sometimes we thought we heard a shrill, bellowing cry, as if indicative of anguish and rage, rising through the gurgling waters. His fury, however, was soon exhausted; in a short time the sounds broke away into distance, and the agitation of the sea subsided. The shark had given himself up to the tides, as unable to struggle against the approach of death, and they were carrying his body unresistingly to the beach."

Crouch, in his "Fishes of the British Islands," would indirectly claim some apology for the habits of the shark tribe; in reference to which he asks why the lion and the eagle should occupy the elevated places they do in popular estimation, as the king of beasts and monarch of the air. They live by the exercise of powers similar to those of the sharks, and if insatiable appetites are to take precedence, sharks ought to stand in the foremost rank.

The appearance of sharks occasionally upon our coast naturally creates a certain panic among bathers; and we may trace the breakage of the nets of our fishermen to their presence, among other causes. The six-gilled shark, or gray shark, is sometimes eleven or twelve feet in length, and is very destructive among the pilchards on the Cornish coast. The white shark is a formidable fellow; but although his class occasionally send over to our isles deputations of one or two, we have, fortunately, not had to record of late years such a visitation as that of 1785, when hundreds appeared in the British Channel. This individual is, perhaps, the most formidable of all the inhabitants of the ocean. Ruysch says that the whole body of a man, and even a man in armor, has been found in the body of a white shark. Captain King, in his "Survey of Australia," says he caught one which could have swallowed a man with the greatest ease. Blumenbach says a whole horse has been found in it; and Captain Basil Hall reports the taking of one, in which, besides other things, he found the whole skin of a buffalo, which a short time before had been thrown overboard from his ship. The blue shark is a horrible nuisance to the fishermen, but, fortunately, it is with us only in summer, when it makes itself known by hunting after the fish entangled in the nets, which it does by seizing both fish and net with its keen and serrated teeth, and swallowing fish and mesh together. As it is not always pleasant to have sharks following a ship, it cannot be too well known that a bucket or two of bilge-water has been known to drive them off.

The shark tribe are remarkably retentive of life, and instances are related which would be almost beyond belief, if not vouched for by numbers of witnesses. For instance, an individual was caught with a line; its liver was cut out, and the bowels left hanging from the body, in which state the sailors, as an object of abhorrence, threw it into the sea. But it continued near the boat; and not long afterward it pursued and attempted to devour a mackerel that had escaped from the net. In another instance, a shark was thrown overboard after the head had been severed from the body; after which, for a couple of hours, the body continued to use the efforts of swimming in various directions—to employ the conjecture of a boy among the crew—as it it were looking for its head. Next, we have the thrasher, which has obtained the name of fox-shark, because of the shape of its tail. The title of thrasher, however, is most appropriate, from its habit of lashing the sea with its tail, by which it has been known to put to flight a herd of sportive dolphins, and even to fill the whale with terror. The porbeagle is another of the shark tribe, and is a common visitor on the western coasts in summer. Then follows that too plentiful and rapacious fish, the toper, known likewise as the white-hound, penny-dog, or miller-dog. However, as it swims deep, it does not do so much injury to the fishermen's nets as some of its congeners. Then we have the smooth-hound, or ray-mouthed dog, or skate-toothed shark, which are presumed to come from considerable distances, from the kind of hooks sometimes found in them, which resemble those used on the coast of Spain. They feed upon crustaceous animals, but will take a bait. The picked-dog, spur-dog, or bone-dog, but commonly known as the dog-fish, is the smallest, but unquestionably the most numerous of the shark tribe. It frequents our coasts all the year round, and even in the severest weather. Then there are the spinous shark, and Greenland shark, which will not be driven away from feeding upon the blubber of a stranded, half-immersed whale, although pierced with spears, but come again to the oleaginous banquet while a spark of life exists. The basking-shark also, occasionally, casts up on our coasts. It is of a large size, is capable of breaking a six-inch hawser, and is only taken with considerable difficulty. Then we have the rashleigh shark, the broad-headed gazer, and the hammer-head or balance-fish, which may be said to complete the list of these occasional unwelcome visitors to our shores.

And now that we have said so much that is prejudicial to the *Squalidæ* or shark community, let us see what we have as a set-off in their favor. As a food for man, the toper is found exposed for sale in the markets at Rome; and in Paris, that city of gastronomy, the small kinds of shark, when divested of their tantalizing titles, are to be detected as *entrées* in the *menu* of many of the most distinguished families. For some years, the dog-fish has afforded lucrative employment during the whole of the summer to the fishermen from the Naze to the Cape. It is, however, mostly smoked, and in this way is considered rather a delicacy. It is also dried and split as stock-fish for consumption in the country, as well as for export to Sweden, where it is greatly appreciated. It is likewise elsewhere a common article of food, amid the choice of a variety of other fish, especially in the west of England, and, indeed, is valued by some who are far above the necessity of classing it with their ordinary articles of subsistence. It is used both fresh and salted, but, when eaten fresh, it is skinned before being cooked. Lacipede, who speaks slightingly of its flesh, informs us that, in the north of Europe, the eggs, which are about the size of a small orange, and consist solely of a pale-colored yolk, are in high esteem. If prejudice could be got over, there is no doubt they would form an agreeable as well as a nourishing article of food, as a substitute for other eggs in our domestic economy.

The shark-fishery is carried on in many parts of the Indian Ocean, and on the eastern coast of Africa, and recently it has been pursued on the coast of Norway. About Kurrachee, in India, as many as 40,000 sharks are taken in the year. The back-fins are much esteemed as a food delicacy in China, from 7,000 to 10,000 of these being shipped to that empire annually from Bombay. In Norway and Iceland the inhabitants make indiscriminate use of every species captured, hanging up the carcasses for a whole year, like hams, that the flesh may become mellow. The liver, however, appears to be strictly prohibited everywhere, as a dangerous article of food.

Mr. N. Brabazon, in his "Fisheries of Ireland," in allusion to the large shoals of sharks which pass annually along the west coast, on their way from the southern to the northern seas, speaks particularly of the basking shark: "These fish are worth from £35 to £50 each; and when so many as five hundred have been killed in one season, this class of fishing should be well attended to for the short season it lasts, if the weather is favorable to it, especially as it is at a time when other fish are out of season. The fishermen have a superstition that the fish will leave the coast if the bodies of those caught were brought to the shore." Mr. P. L. Simmons, in his "Waste Products and Undeveloped Substances," gives almost incredible statistics of the vast amount of fish-refuse which is either left to rot on the coasts and putrefy the air, or thrown back into the sea unutilized, both on our own and on foreign shores; and he significantly points to its value as a manure not far inferior to guano, of which this country alone requires 200,000 tons a year, and pays upward of £22,000,000. Would it not, therefore, be wise for enterprise and capital to begin to turn more attention to the manufacture of fish-guano, of which the *débris* of the North American fisheries, and those of the North Sea, would furnish ample material?—*Chambers's Journal.*

ABORIGINAL SETTLEMENTS OF THE PACIFIC COAST.

By PAUL SCHUMACHER.

If we investigate the condition of the ground upon which we now find the ruined settlements of a former people on this coast, it cannot fail to convince us either that all such stations had been established on sandy ground, or that the ground had been artificially changed by sand carried thither when it was rocky or hard. Sandy soil was a necessity, that they might employ their rude and imperfect tools in the erection of houses partially dug in the ground and surrounded by embankments. It was also a requirement for cleanliness and health, owing to its absorption of moisture in the rainy season. Overgrown or firm sandy ground was preferable to bare, loose sand; but even the drifting dunes offered them a better choice than the dark humus intermixed with rock. Other requirements of a well-located *ranchería* were: proximity of potable water, a commanding view, the outlying rocks bearing eatable mollusks, fish in the adjoining kelpy waters, and game in the neighboring country. Water in small rivulets and springs was preferable to larger streams and rivers, unless these were stocked with fish. A commanding view was subordinate to the condition of the soil and the proximity of water, especially on the islands in Santa Barbara Channel, where no surprising enemy was to be guarded against; there a small boat-landing was one of the main considerations, because the islander's sustenance was mainly derived from

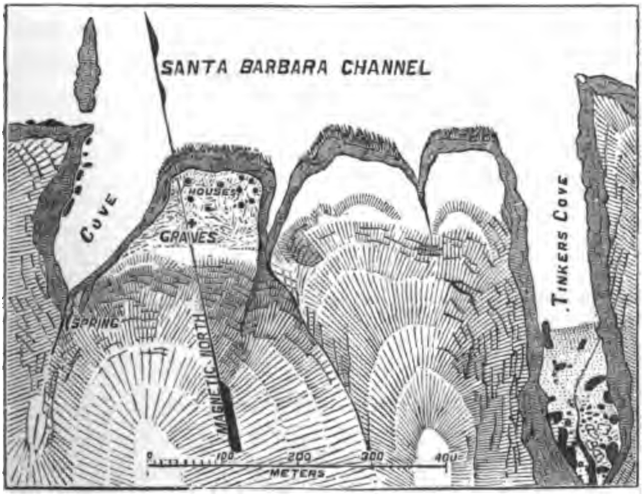

FIG. 1.

fishing, hunting on the water, and barter with the dwellers on the mainland. To gather shell-fish the aborigines often went long distances, which called into existence temporary camps wherein we hardly find anything but layers of shells and some burned beach-rocks, indicating former fireplaces, scattered in small clusters over their surface. The mollusks, after their shells had been removed, were dried in such temporary camps for easier transportation to distant villages.

But let us examine one of the sites of such aboriginal villages, commonly termed "shell-heaps" or "shell-mounds," bleached shells being by far the larger and more conspicuous part of their remains. I will select one of the many stations which I have investigated for the Smithsonian Institution during recent years. Its location is near a narrow inlet, called Tinker's Cove, on the island of Santa Cruz, one of the group in the Santa Barbara Channel (*see* Fig. 1). It possesses all the requirements of an aboriginal settlement, only the game-ground is wanting, as no animals save a small gray fox, and several species of land-birds, exist on the islands. The ground upon which the station is located is of a rocky, irregular structure, mostly bare and destitute of vegetation; a cove, affording an excellent boat-landing, adjoins to the westward of it; outlying rocks, of which but few appear in the sketch, are covered with edible shell-fish; a mass of kelp and sea-weed grows in the adjoining waters, and is thickly stocked with fish; a spring of potable water is found in the deepest part of the cove. Sand is found only at a distance of between four and five hundred yards to the eastward, in a small hidden beach of the narrow fiord of Tinker's Cove, which is of very difficult access by land, as the sides of the inlet form walls of over one hundred feet in height, and in larger quantities farther away to the westward of the station. It is,

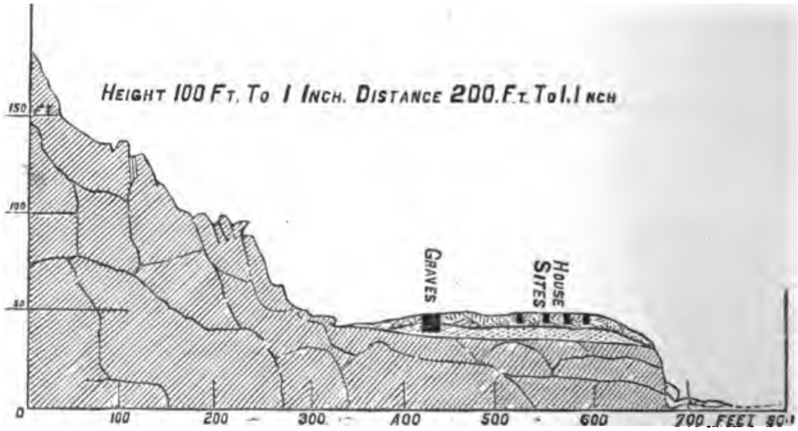

FIG. 2.

therefore, evident that the layer of sand covering its rocky ground is artificial, and placed there by the aborigines, not a natural deposit accumulated by drifts, etc. The mound begins at the brink of the bluff, some thirty feet above high-water mark, and extends back over a flat of a little more than one hundred yards, toward the ascending hill, diminishing gradually in height, and ceasing entirely before the rocky outcroppings are reached, whence the ground rises rapidly into a ridge, forming a spur of the backbone of the island (*see* Fig. 2). Investigation revealed the artificial formation to consist of a layer of shells, most of which are still found among the living species on the island, bones of fish, sea-fowl, seal, and sea-lions, and whales, dogs and foxes, and a great mass of cobble-stones of all sizes, especially of the size of a fist as used for fireplaces, and chippings of different varieties of chert, chalcedony, jasper, quartz, etc.—rocks suitable for the manufacture of knives, arrow-heads, spear-points, and other cutting tools, which do not occur *in situ* on the island and had to be imported. The whole is mixed with a large quantity of sand, reaching to a depth of about five feet at its deepest part, where formerly the dwellings stood. Underneath the layer of animal remains, the kjökken möddings—kitchen-middens or cooking *débris*—of a former people, pure sand is met in which we find but few valves of an edible shell-fish, or beach-rocks showing marks of fire, or such marks as are made by human hands, and were probably introduced while the dwelling-mound was raised preparatory to the erection of the hut. The sand—which was either carried there overland, or in canoes from some neighboring sand-bank—attains a depth of about three to four feet, and is deepest around the circular depressions of the house-sites, indicating the embankments which had been raised around the huts. The section, Fig. 3, represents a site of a former dwelling as now found, and its original depth, as indicated by broken lines, may occasionally be traced by still remaining upright boards of the former subterranean inclosure. After the erection of the dwellings, the accumulation of the kjökken möddings began to spread all over the town-site, but was kept imbedded in sand by fresh supplies, thus raising the level of the village gradually, and increasing the depth of the subterranean part of the hut until the latter was deserted, or built over with a new structure.

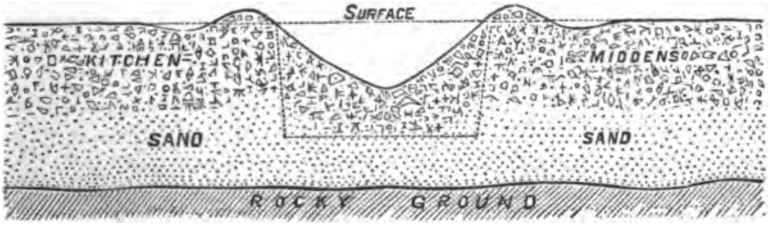

FIG. 3.

Near the houses, where in all probability the cooking *débris* had first been deposited, it is now and then found in heaps almost destitute of sand; but, no doubt, after a large quantity had thus been accumulated, it was spread over the ground of the town, evened, and smoothed by layers of sand. The proportion of sand mixed with the cooking *débris* is about one-half the weight of the whole mass. The size of a town-site varies from about 100 metres in length and width, like the one illustrated in the figure, to 1,200 metres, or three-quarters of a mile, in length, and from 100 to 300 metres in width, the extent of *Os-bi*, a *ranchería* in Santa Barbara County, about five miles south of Point Sal, which is the largest shell-mound derived from permanent habitation thus far explored on this coast.

The same features of an aboriginal settlement we observe in Oregon, 1,000 miles to the north. If we take, for instance, the ruined settlement of the *Chetl-e-shin*, situated on the commanding elevation of the north bank, and near the mouth of Pistol River: in front the wide ocean expands, with a number of large outlying rocks; Pistol River washes the base of the bluff upon which the station is situated; its waters are stocked with trout, and, in certain seasons, abundantly with salmon; to the left, or eastward, a mountain-brook empties into the river at the foot of the *ranchería*, and a spring issues between the upper and lower town-sites; back of the coast the country extends in a gradual rise toward a steep and heavily-timbered ridge, beyond which it becomes almost impenetrable, owing to thick forests and their undergrowth, and vines, the safe home of elk and bear. The rocky ground upon which the town was located is covered with a deposit of sand, of which the neighboring beach offers an abundance, and kjökken möddings of great age in its lower layers, with that peculiar mouldy, ash-like appearance, sprinkled with particles of decayed shells, so characteristic of an aboriginal settlement.

It is evident that such a ground, needing artificial foundation for the establishment of a town, was not suitable either for a burying-ground site; we must, therefore, look for the graves of these people within the artificial mounds. There is an exception to this when the ground is naturally sandy, or soft; then we must look for the graves within an easy distance, say about 150 metres, in some prominent place and in sight of the *ranchería*. The graves consist of a pit varying between two and fifteen metres square, and not over two metres in depth, partitioned into smaller spaces by whales' bones and slabs of stone, or by wood. On the islands the gigantic bones of the whale are almost exclusively used; while, on the neighboring mainland, limestone, which splits board-like into slabs, and also whales' bones, and pine and red-wood, are used. Graves of this description have been found in California south of San Francisco, while in Oregon the mode of burial is different, the interment being either made in detached graves, or in houses previously demolished by fire.

SKETCH OF SIR WILLIAM THOMSON.

THIS distinguished physicist and mathematician was born in Belfast, in June, 1824. His father, Dr. James Thomson, was a man of large capacity and culture, who studied in the Glasgow University, became head-master of the Belfast Academical Institution, and in 1832 was appointed Professor of Mathematics in the University of Glasgow. He made various improvements in mathematics, and wrote books upon education. William passed through the Glasgow University early, and then entered St. Peter's College, Cambridge, from which he graduated as second wrangler in 1845, and he was immediately elected Fellow of his college. He afterward went to Paris, and worked in the laboratory of Regnault. In 1846, at the early age of twenty-two, he was appointed Professor of Natural Philosophy in the University of Glasgow, a position which he has filled with distinction, and still occupies.

Sir William Thomson's earliest contributions to physical science were on the subject of heat, the laws of its motions being treated mathematically. A remarkable paper on "The Uniform Motion of Heat in Homogeneous Solid Bodies," written at the age of seventeen, was full of original conceptions, but it was afterward found that Thomson had been anticipated in his ideas by Gauss, Chasles, and George Green, of Nottingham. In 1842 he published an important paper on "The Linear Motion of Heat," which contained a method of deriving geological dates from underground temperatures, a subject which he treated in his inaugural address, in entering upon his professorship at the university.

It will be impossible here to give any account of the numerous contributions to science made by Sir William Thomson, as they were generally of so mathematical a cast as to be unintelligible to ordinary readers. His papers on "Electro-Statics" and on "Magnetism" were collected and published in 1872, in a valuable volume of six hundred pages. The more interesting aspects of his work have been well described by a writer in *Nature*, and we cannot do better than to quote some passages from his notice:

> "His electrostatic researches led Thomson to the invention of very beautiful instruments for electrostatic measurement. The subject of electrostatic measurement occupied much of his attention from the very earliest, when he was obliged to call attention to the defects of the electrometers of Snow Harris. His labors in this direction have produced the quadrant electrometer, which is employed for all kinds of electric testing in telegraph construction, and for the registration of atmospheric electricity at Kew Observatory; the portable electrometer, for atmospheric electricity and for other purposes, in which the extreme sensitiveness of the quadrant-electrometer is not required; and the *abso-*

lute electrometer, which serves for reducing the scale-readings of other instruments to absolute measure, and which was used by Thomson in his measurement of the electrostatic force producible by a Daniell's battery and in many other investigations. Those who have seen the collection of electrometers in the Loan Collection at South Kensington will not think it too much to say that to Sir W. Thomson is due our present system of practical electrometry.

"But while thus engaged in investigations in electrostatics and magnetism, there were many other branches of science that were receiving from him advancement in a not less remarkable way. There is no part of his work of higher importance than his investigations on the Dynamical Theory of Heat. These were communicated in a series of papers to the Royal Society of Edinburgh, the first of which was given in 1849. It was a critical account of Carnot's memoir of 1824, 'Réflexions sur la Puissance Motrice du Feu.' Though Rumford and Davy had, in the beginning of this century, experimentally disproved the material theory of heat, their experiments and arguments were unheeded and nearly unknown; and it was only after 1843, when Joule actually determined the dynamical equivalent of heat, that the great truth that heat is a mode of motion was admitted and appreciated. Thus Carnot, although dissatisfied with it, was obliged to adopt the material theory of heat in 1824; and, regarding heat as indestructible, spoke of the letting down of the heat from a higher to a lower temperature, and looked on the production of work by the heat-engine as a phenomenon analogous to that in which water, descending from a higher to a lower level, does work by means of a water-wheel. Thomson, among the first to appreciate the importance of Joule's results, set himself to alter the theory given by Carnot into agreement with the true theory; and in the series of papers referred to, placed the whole science of thermodynamics on a thoroughly scientific basis. In 1846 he first suggested the reckoning of temperature on an absolute thermodynamic scale independent of the properties of any particular substance. Subsequently, in consequence of experimental investigations of the thermodynamic properties of air, and other gases, made in conjunction with Joule, he showed how to define a thermodynamic scale of temperature having the convenient property that air-thermometers and other gas-thermometers agree with it as closely as they agree with one another. This system of reckoning temperature gives great facility for the simple expression of thermodynamic principles and results.

"Having here mentioned Joule and Thomson together, we cannot omit to remark that some of the most admirable researches in thermodynamics were those undertaken in conjunction by these two attached friends.

"Among the many important results of Sir W. Thomson's investigations in thermodynamics, one of the most remarkable was his discovery of the principle of dissipation of energy, announced by him in 1852. During any transformation of energy of one form into energy of another form there is always a certain amount of energy rendered unavailable for further useful application. No known process in Nature is exactly reversible, that is to say, there is no known process by which we can convert a given amount of energy of one form into energy of another form, and then, reversing the process, reconvert the energy of the second form thus obtained into the *original quantity* of energy of the first form. In fact, during any transformation of energy from one form into another, there is always a certain portion of the energy changed into heat in the process of conversion; and the heat thus produced becomes dissipated and diffused by radiation and conduction.

"Consequently, there is a tendency in Nature for all the energy in the universe, of whatever kind it be, gradually to assume the form of heat, and, having done so, to become equally diffused. Now, were all the energy of the universe converted into uniformly-diffused heat, it would cease to be available for producing mechanical effect, since for that purpose we must have a hot *source* and a cooler *condenser*. This gradual degradation of energy is perpetually going on; and sooner or later, unless there be some restorative power, of which we at present have no knowledge whatever, the present state of things must come to an end.

"In 1854 Faraday, with an experimental cable, investigated the cause of the *retardation of signals* first observed in the working of the cable between Harwich and the Hague. Thomson, taking up the question, published an investigation of the nature of the phenomenon, one practical result of which was that with cables similar in lateral dimensions the retardations are proportional to the *squares of the lengths*. This law is now commonly referred to as the 'law of squares.' About this time it was proposed to construct a cable to connect England with America; and it became obvious that the discovery of the retardation of signals raised a question whether the transatlantic cable would not prove a commercial failure. Whitehouse, experimenting with 1,125 miles of cable, found the transmission of an instantaneous signal to the farther end of the cable to occupy one second and a half. The length of a cable required to connect Ireland with Newfoundland is twice that of the experimental cable of Whitehouse; and thus, according to the law of squares, the time taken to transmit an instantaneous signal through a cable similar in lateral dimensions to that of Whitehouse, and joining those two places, would be no less than *six seconds*. In 1856 Whitehouse read a paper before the British Association, in which he described experiments by which he hoped to disprove the law of squares. Thomson replied in the *Athenæum* (November 1, 1856); and subsequent experiments have established the correctness of his law.

"Fortunately a true understanding of the nature of the phenomenon of retardation led Prof. Thomson to the method of overcoming the difficulties presented. The disturbance produced at the extremity of a long submarine cable by the application for an instant of electromotive force at the other end is not, as in the case of a signal through an overhead land-line, a pulse, practically infinitely short, and received only a minute fraction of a second after it was communicated. Instead of this, a long wave is observed at the farther extremity, gradually swelling in intensity, and as gradually dying away. Its duration for such a cable as we have been speaking of would be the whole six seconds, calculated from the experiments of Whitehouse. Prof. Thomson perceived that an instrument was required which should give an indication of a signal received long before the wave has acquired its maximum intensity, and in which the subsequent rising to maximum intensity should not render unreadable a fresh signal sent quickly after the previous one. This was effected by his 'mirror galvanometer;' and it was by means of it that the messages transmitted through the 1858 Atlantic cable were read.

"The 1858 cable, submerged under difficulties that many times threatened to be insurmountable, soon failed. Several important messages were, however, transmitted through it; and it served to *prove* the feasibility of the project which many eminent engineers up till that time regarded as chimerical. Before another attempt was made the labors of Prof. Thomson and others, to all of whom the world owes a deep debt of gratitude, had so improved the construction of the cables and the mechanical arrangements for submersion, that though many difficulties presented themselves they were all, in 1866, triumphantly overcome. It was on his return from the submersion of the 1866 cable, and the raising and the completion of the 1865 cable, that the honor of knighthood was conferred on him along with others of his distinguished fellow-workers.

"Recently Sir William Thomson has invented a new and very beautiful instrument, the 'siphon recorder,' for recording signals on long submarine lines. It is in use at all the telegraph-stations along the submarine line connecting England with India. It is also used on the French Atlantic Cable, and on the direct United States line. Sir W. Thomson, Mr. Varley, and Prof. Jenkin, combining their inventions together, have given the only system by which submarine telegraphy on long lines has been carried on up to the present time.

"Sir William Thomson is an enthusiastic yachtsman and a skillful navigator. His recently-published popular lecture on 'Navigation' proves this; and, with that bright genius which enriches all with which it comes in contact, his improvements in navigation are of very high importance. The general adoption of Sumner's method, now made simple for the navigator, would be a reform in navigation almost amounting to a revolution, and is one most highly to be desired. Sir William Thomson has also invented a new form of mariner's compass of exquisite construction. It possesses many advantages over the best of those in general use, not excluding the Standard Admiralty Compass; but its special feature is that it permits of the *practical* application of Sir George Airy's method of correcting compasses for the permanent and temporary magnetism of iron ships. He has also invented an apparatus for deep-sea sounding by piano-forte wire. This apparatus is so simple and easily managed that he has brought up 'bottom' from a depth of nearly three nautical miles, sounding from his own yacht, without aid of steam or any of the ordinary requisites for such depths. His method was much employed in taking rapid soundings during the laying of telegraph-cables along the Brazilian coast to the West Indies. It has also been used with great success on the United States Submarine Survey. Recently, while on his way to Philadelphia, Sir W. Thomson himself was able to take flying soundings, reaching the bottom in sixty-eight fathoms, from a Cunard Line steamship going at full speed.

"Sir William Thomson is a Fellow of the Royal Society of London and of the Royal Society of Edinburgh. He has received the Royal Medal of the former and the Keith Medal of the latter. He is also an honorary member of several foreign societies. The Universities of Dublin, of Cambridge, and of Edinburgh, have each conferred upon him the honorary degree of LL. D., and that of Oxford the honorary degree of D. C. L. On his marriage in 1852 he gave up his fellowship at St. Peter's College, Cambridge; but in 1871 his college again elected him to a fellowship, which he now holds."

CORRESPONDENCE.

INSECTS AND FLOWERS IN COLORADO.

To the Editor of the Popular Science Monthly.

IN my paper on "The Fertilization of Flowers by Insect Agency" ("Proceedings of the American Association for the Advancement of Science," 1875, pp. 244, 245), I say: "On my first visit to the Rocky Mountain region, the absence of insects proved very annoying to the entomologists who accompanied me. Indeed, the paucity of animal life of all kinds in the Rocky Mountains is well known; but there is no more scarcity of seed in the colored flowering plants than in similar ones elsewhere." At the conclusion of my address, Prof. Riley objected to the accuracy of this statement—not from his own personal experience, as I believe, and from overlooking, as I supposed, that I was referring to insects relating to the cross-fertilization of flowers—chiefly *Hymenoptera* and *Lepidoptera*. Mr. Charles R. Dodge, editor of *Field and Forest*, was one of the entomologists I referred to. In vol. i., No. 12, page 89, he describes that expedition in the summer of 1871: "The route carried us through Golden City and Idaho Springs to South Park, thence to Pike's Peak and the Garden of the Gods, where we emerged from the mountains and returned to Denver over the level plateau known as the 'Divide;' and, from the time we passed the foot-hills near Golden City, and entered the first cañon in the mountains, we were struck with the comparative paucity of the insect fauna. . . . In the mountains, the marked *absence* of insect-life in variety, except in favorable localities, was the rule, and not the exception." Traveling was not so easy then as now, and I think it took us nearly three weeks. The party comprised thirty persons, all of whom were interested in aiding the collectors. Mr. Dodge sums up his remarks by especially noting that "the entire mountain-trip yielded so small a number of nocturnal *Lepidoptera* that they are hardly worth mentioning." He adds, "I have conversed with a few other entomologists on this subject, and they agree with me perfectly."

Now, if we turn to Hayden's "Report of the Survey of Colorado," for 1873, we find Lieutenant Carpenter substantially recording the same thing. Here are the doings of a whole season, and not for three weeks merely, and only five species of butterflies are found; and, indeed, he remarks that "*Lepidoptera* are undoubtedly peculiar to high latitudes and great elevations." This leaves us with scarcely anything but bees to do the whole work of flower-fertilization in the Rocky Mountain region. But even these seem to be confined to some considerable elevation. In an expedition in 1873 I saw *Bombus termarius* in abundance, but on no other flowers than *Polygonum bistorta*, on Gray's Peak, on the flats near the timber-line. I was struck by the fact that they seemed to visit only this species, evidently getting all they required from it, and neglecting everything else. I did not see bees anywhere in our expedition of 1871 in lower altitudes, nor do I think there were any in 1873, except in this high region near the timber-line. Of course, there might have been, but, if so, they were so scarce as to attract little attention. This seems to have been the experience of Lieutenant Carpenter. He says, "The humble-bee was always to be seen in midsummer at the verge of the Alpine flora, busily engaged in collecting its store of pollen from the few flowers to be found." This does not certainly say they might not be found lower down, but it is a fair inference. My collections in this district embraced over seven hundred species of flowering plants and ferns. I can say that among these were quite as large a proportion of colored flowers as in an equal number gathered East, where insects are conceded to be numerous.

But just here Prof. Gray steps in with the following note: "*À propos* to Mr. Meehan's suggestion that, although the Alpine plants of the Colorado Rocky Mountains are mostly high colored, insects are there so rare that they can be of no material aid to fertilization, and therefore these plants must self-fertilize, it may not be amiss to introduce testimony. An entomologist now at my side, who has passed four summers among these mountains, and made frequent visits to the Alpine regions, informs me that 'he has always found insects of all orders quite abundant in the Rocky Mountains'" (*Silliman's Journal*, 1876, pp. 397, 398). The route which I have described can hardly be called the "Alpine" region, unless it be in so far as it relates to Pike's Peak, which, however, I did not join my companions in ascending, having chosen in preference to explore alone what was then an unknown cañon, and which I named after my good friend Dr. Engelmann, whose name it still bears. There is nothing in my paper, as referred to by Prof. Asa Gray, to warrant the statement that I was confining myself to "Alpine" regions. Indeed, the "suggestion," so far as it relates to the paucity of insects, should refer to the "entomologists who accompanied me," and not to myself. All I claim is that the "entomologists" found no insects, while I found colored flowers seeding abundantly.

In view of the testimony of the entomologist at Dr. Asa Gray's side, that insects of all orders are quite abundant in the Rocky Mountains, I should be glad to have, through THE POPULAR SCIENCE MONTHLY, a list of the *Hymenoptera* and *Lepidoptera* that are abundant enough, in the particular part of the Rocky Mountain region covered by my experience, to probably act as cross-fertilizers of flowers, noting those which may perhaps be introduced since 1871, as it is well known that, with the introduction of agriculture and horticulture, insects often follow.

I do not suppose that, in the large number of observations I have placed on record, there will not be now and then one found "imperfect." Not one of us who are working in this field but, with all our care, must expect such annoyances. As the relation of insects to plants in the flora of Colorado is an important one, and I never heard the view I have taken of it questioned except as now stated, I think it important to science to know exactly how far my statement is imperfect, if imperfect at all. THOMAS MEEHAN.

GERMANTOWN, PA., *November* 27, 1876.

THOMAS CARLYLE AND THE DARWINS.

To the Editor of the Popular Science Monthly.

THERE are floating in the American press some ill-natured remarks of the octogenarian, Carlyle, that merit a little attention. The remarks reported are as follows: "I have known three generations of the Darwins—grandfather, father, and son: atheists all. . . . I saw the naturalist not many months ago; I told him that I had read his 'Origin of Species' and other books; that he had by no means satisfied me that men were descended from monkeys, but had gone far toward persuading me that he and his so-called scientific brethren had brought the present generation of Englishmen very near to monkeys. A good sort of a man is this Darwin, and well-meaning, but with very little intellect."

REMARK 1. If a "very little intellect" can change the present generation of Englishmen to monkeys, what are those Englishmen made of?

REMARK 2. Carlyle has known the three generations of the Darwins, beginning with the grandfather. Erasmus Darwin, the grandfather, died in 1802, about six or seven years after Carlyle was born! Is it exactly the right thing for the old gentleman to say he knew him?

REMARK 3. "They are atheists all." Now, two years before Mr. Carlyle was born, to wit, 1794, the grandfather, Erasmus Darwin, published the great work of his life, "The Zoönomia, or Laws of Organic Life," and on the first page he says: "The great Creator of all things has infinitely diversified the works of his hands, but has, at the same time, stamped a certain similitude on the features of Nature, that demonstrates to us that *the whole is one family of one parent.*" And, on page 77, he says expressly: "I do not wish to dispute about words, and am ready to allow . . . and to believe that the ultimate cause of all motion is immaterial, that is, God." Mr. Carlyle may be a well-meaning man, but his knowledge of that grandfather, although at the ripe age of six years, must have been rather imperfect.

But the charge of atheism includes the naturalist, Charles Darwin. The candid readers of Charles Darwin's works know better. Many people, on reading the books of Genesis and Job, grow skeptical; but no one who reads the marvelous revelations of the works of God which this learned naturalist has published can for a moment doubt the existence of the divine wisdom which pervades the realms of Nature.

R. M. K. ORMSBY.

CHESTER HILL, N. Y., *November* 27, 1876.

To the Editor of the Popular Science Monthly.

DEAR SIR: In a letter addressed to you, and published in your columns, from the pen of Thomas Meehan, Esq., in which he is "getting right on the record," I am disturbed by the following expression in reference to my Buffalo address: "Prof. Morse could only help me with the audience by remarking, 'We all know that Mr. Meehan is a Darwinian, and an evolutionist, but must say he has an odd way of putting it.' That my good friend does not regard me as much of either is, however, clear, from his making no reference to any of my labors in his 'History of Evolution.'"

The reader of this might think that I had either overlooked the interesting contributions of Mr. Meehan in the "Proceedings" of the Philadelphia Academy, and his own journal, or else had done him a manifest injustice. That I am not guilty, either of oversight or injustice in this matter, the following lines from my Buffalo address will prove: "A review of the work accomplished by American students, bearing upon the doctrine of descent, must of necessity be brief. Even a review of a moiety of the work is beyond the limits of an address of this nature. *And for obvious reasons I must needs here restrict it to one branch of biology, namely, zoölogy.*" The *obvious reason* is that I am not a botanist, therefore no reference is made to the works of Dr. Gray, Mr. Meehan, Prof. Beal, and others, who have made valuable contributions to the subject. In the solitary case where I alluded to the fertilization of yucca, it was to show the curious moth *Pronuba*, so admirably described by Prof. Riley, as an insect showing peculiar adaptations for the work in hand.

EDWARD S. MORSE.

SALEM, MASSACHUSETTS, *November* 4, 1876.

EDITOR'S TABLE.

PHILANTHROPIC FANATICISM AGAINST SCIENCE.

REFERENCE has been repeatedly made in our pages to an English Parliamentary Commission, appointed to inquire into the practice of vivisection, or experiments upon living animals, made for scientific purposes by the physiologists of that country. The inquiry was the consequence of a prolonged and intense public agitation, in which the sympathies of the people were excited, and their indignation aroused, by frightful stories of cruelty deliberately and wantonly perpetrated upon innocent animals under the pretext of advancing scientific knowledge. The movement was systematically and skillfully engineered by those who make philanthropy a business. Money was plentifully contributed by the rich to carry it on, and with plenty of money there is never any difficulty in engaging the press in a good work. Appealing to the sensibilities by exaggerated accounts of the way poor animals were tortured, the subject naturally took a deep hold of the sympathies of women, and its measures were promoted and sustained by many ladies of wealth and high social position, and were understood to be warmly encouraged by the queen herself. But the humane feelings of both sexes were profoundly stirred by the tales of atrocity that were circulated, so that the scientific physiologists of the country began to be looked upon as fiends, reveling in the infliction of agony upon helpless animals. The stories, of course, were unscrupulous exaggerations, or arrant lies, but the public is a great believer and fond of pungent sensations, while fervid philanthropy is not apt to trouble itself much about cool matters of evidence.

The Parliamentary Commission, constituted of both the enemies and the friends of vivisection, at length took the matter up, and, as is customary with English commissions, it made a thorough investigation. Witnesses on both sides gave voluminous testimony on all aspects of the subject, and after patient and impartial consideration the body made a report which was designed to be preliminary to legislation upon the question. As regards the merits of the controversy, it was agreed that vivisection, or operations upon living animals, is a necessary and a proper thing, and, as practised by scientific men, has been of great use to the world. The commission, moreover, entirely acquitted the physiologists of the charge of cruelty. It commended the humanity of the medical profession in England, and testified that medical students were extremely sensitive in regard to the infliction of pain on animals.

One would think that with this decisive expression on the general subject, and with this complete vindication of the aspersed parties, the agitators would have been rebuked, and the case at once dismissed. But the anti-vivisection movement was quite too formidable to allow of this. That hysterical rampage of British philanthropy was strong enough to coerce the Government against its own protestations, and to extort from it a law that was alike an insult to science and a disgrace to the country. The physiologists were expressly acquitted of all improper practices when left free as they had always been to pursue inquiries in their own way, and they were then handed over to the future control of the police. They were vindicated from all imputation of cruelty, and then subjected to the operation of a statute against cruelty to animals. Though their experiments had for their object the ultimate mitigation of pain to the higher creatures most susceptible of pain—though their investigations were of so beneficent an influence that, as Prof. Tyndall justly says, "no greater calamity could befall the human race than the stoppage of experiments in this direction"—yet the physiologists were classed by law with those cold-blooded brutes who cruelly overdrive, abuse, and torture domestic animals. Though the necessity, and form, and extent of his experiments on animals were, in the nature of the case, matters of which the operator alone could judge, as their essential object is the elucidation of undetermined problems, yet it was legislated that he should not pursue his work except by a license from a political office-holder, and the making of any experiment calculated to give pain to an animal was declared an offense punishable in the first instance by fine, and in the second by fine and imprisonment, unless certain conditions were complied with to the satisfaction of the said political functionary who was put in control of the whole business. In short, legislative wisdom, stimulated by philanthropic zeal, outlawed vivisection as a crime, and then provided for its perpetration by leave of the Secretary of State.

Let us now see how much there was of real philanthropy or of hearty sympathy for the sufferings of the lower animals at the bottom of this movement. Had it been sincere, or based upon principle, it would have undoubtedly aimed to be effectual, and to have inflicted the penalties for cruelty alike upon all delinquents. But the law was so framed as to bear hard only upon the poor, and to give a virtual license to the rich, who could easily pay the fines prescribed for inflicting whatever cruelties they chose. Again, the law passed was intended, by the terms of its title, to prevent "cruelty to animals;" but a clause was quietly introduced at the end limiting it to the protection of *domestic* animals only—a clause which stultified the enactment, and showed the emptiness of its purpose by exposing immensely the greater portion of the inferior animate creation to all the wantonness of torture; and not only that, but to tortures that were sure to be inflicted, and were provided for by the limitations of the statute. Of the sufferings to which certain of the lower animals are subjected by the favorite English pastime of hunting them with hounds, which is freely permitted by law, we do not speak, but will only refer to some facts regarding the universal English sport of "shooting." It is well known that the British Parliament generally adjourns about the time that the partridges and grouse cease to be protected by the game-laws of the country; and no one who knows anything of the strength of British instincts for destructive field-sports will consider the connection, in this case, as altogether fortuitous. Lords, Commoners, and everybody that can afford it, then seize their guns, and betake themselves to the fields and mountains wherever there is anything to be killed. It is the fashionable and the national thing. Those who own grounds range over them with their guests in quest of beasts and birds, and others hire the privilege of doing it for longer or shorter times. The whole matter is legally regulated. Licenses are issued to keep guns, and licenses to kill game. A few of all the multitudes who enter upon the sport are good shots, and kill a large portion of the creatures fired at. But the most of them are bad shots, and wound many more than they kill. When hit, if not captured, they escape with their bodies penetrated with leaden pellets—some of them to die; some to suffer miserably; and others to recover after experiencing various degrees of pain. A writer in *Nature* has gone into the statistics of shooting, with a view to estimate the probable numbers of creatures that thus suffer by wounding. He adopts as his basis the number of those who take out licenses, the duration of the season, and the days given to sport, and, by reckoning the number wounded per day that are not killed, he arrives at a proximate conclusion regarding the aggregate of animals that yearly suffer from this cause. The number of licenses issued is taken from government reports, which indicate, for example, that in the year 1873–'74 there were 132,036 holders of gun-licenses, and 65,846 holders of licenses to kill game. Assuming that each sportsman wounds three head of game per day, which are not taken, he finds that the total number of animals upon which pain is thus inflicted amounts to many millions annually. We cannot go into the details of his calculation, which is carefully and fairly made out, but will quote the concluding passage of his article:

> "If we may trust our figures, here are the plain facts that acute pain of uncertain duration was, in the year ending March 31, 1874, inflicted upon *over twenty-two million* animals, and in the following year upon *over twenty-three million and a half*, in the British Islands. We are not aware that we possess any bias that would make us exaggerate our estimates to produce these results. Our only object is to attempt as near an approximation to the truth as we can. The figures stand for themselves, and if any one thinks he can furnish fairer averages let him give his data for them. We are, as it is, willing to guard against any unconscious exaggeration, and to knock off more than ten per cent. of our grand totals, so as to say roundly that only twenty millions have suffered in each year. But we would invite our readers to reflect on the proportion which even that number bears to the number of animals which during the same time have been subjected to experiment by the physiologists of this country. The latter have been by many excellent persons held up to obloquy as monsters of cruelty. If this has been done justly, what must they think of those who use the gun?"

From the point of view here presented, the state of the case has been pithily summed up by Mr. Lowe, in a recent able article in the *Contemporary Review:*

> "According to present British law, as revised under the spur of the latest philanthropy, it appears that, while the man of

science must not inflict the least pain on any animal for the most beneficent object, any one else may inflict the most exquisite tortures on any non-domestic animal—that is, on ninety-nine hundredths of the brute creation—without any punishment at all. If he can show that the torture was inflicted from cruelty, from gluttony, for money, for amusement—for any motive, in fact, except a desire to do good by extending knowledge—he enjoys the most perfect impunity; but woe to him if in his infliction of pain there is any alloy of science!"

An attempt was made to protect animals from pain against the sportsman as well as the man of science, by putting both upon the same footing as regards penalties, but it failed. Mr. Lowe says:

> "A motion to extend the law which forbade the cruelly abusing or torturing any domestic animal, to animals non-domestic, and to increase the penalty to a level with the penalty imposed for performing a painful experiment, was lost by a large majority, the Government voting against it. . . . The efforts, therefore, of the two Houses of Parliament to introduce humanity into our laws, as regards animals, stands thus:
>
> "1. Absolute liberty to torture all non-domestic animals except by way of scientific experiment.
>
> "2. Practical liberty for any one who can afford to pay five pounds to torture domestic animals except by way of scientific experiment.
>
> "3. No punishment for painful experiment except by leave of the Secretary of State."

Now, politicians are not partial to science, but the British Government would never have committed itself to such ridiculous legislation except for the pressure of a fanatical agitation which grew out of no real sympathy with the sufferings of the lower animals. Had it been so, the crusade would have been directed against sportsmen for their extensive and selfish infliction of cruelty, rather than against the physiologists for the small amount of pain which they caused, and that, too, in the unselfish and beneficent pursuit of knowledge which is designed to mitigate human suffering and save human life. The agitation was incited by fictitious horrors, and was worked up and sustained in a business way by practised manipulators of popular passion and prejudice. It was directed against a certain class of scientific men, and had its chief root in those narrow prejudices against science which the press and the pulpit have recently done so much to nourish and sustain. There has been an especial dread of biological science, because it meddles with the mysteries of life, and aims to explain things which ignorance and superstition would rather not have explained. Experiments upon animals are looked upon with abhorrence, not solely because of the creatures' suffering, but also because the knowledge thus deduced and applied to man is held to be derogatory and degrading to his nobler nature. The anti-vivisection movement, in short, was very much a result of that feeling of jealousy and hostility toward science which is by no means confined to the ignorant classes, and which it was not difficult to inflame into the fanatical intensity of an aggressive and intolerant popular movement.

POLITICAL ECONOMY IN THE UNITED STATES.

The hundredth anniversary of Adam Smith's "Wealth of Nations" has been the occasion in England of a pretty careful review of the science which he founded—its methods, its province, its achievements, and its prospect of future usefulness—with the result, not of reaching definite conclusions, but of revealing very wide differences of opinion as to what political economy really is. The general tone of the discussion is decidedly doleful; dissatisfaction with the present and doubt as to the future being the only points upon which there is unanimity. Politicians and newspapers alike declare that the centennial marks the decline and not the consummation of the "dismal science;"

that the points of the present controversies are not of the same importance as those of earlier days; that there remains not much to be done in the way of direct legislation; in short, that its great work is done.

In a sense this may be said to be true. The repeal of usury and corn laws, and the establishment of free trade, *was* a great work; and in many minds this practical application of principles stood for the science. Being accomplished, it forms so essential a part of the commercial policy of the country, and has become so rooted in the minds of the present generation, that the value of the benefits derived is not duly appreciated, nor the importance of extending this work to other countries sufficiently recognized.

Economical reform in England has reached that critical period, which comes in the history of all reforms, when effort has been crowned with success. Its old rallying-cries have lost their potency because the ideas which they represented have become universally-accepted axioms; the evils which it labored to correct no longer exist; its champions find their old weapons useless, and no new ones are, as yet, fitted to their hands.

Naturally, this chaotic condition has begotten dissension and revolt, even among those who are by no means willing to admit that the functions of the science have become unimportant; the ranks of the faithful have fallen into disorder; rival sects have arisen, and the validity of time-honored tenets is discussed with earnestness if not with heat. The orthodox school still holds in the main to the old creed; while the dissenters, styling themselves the Historical School—a name the fitness whereof their opponents decline to allow—denounce this creed as being based upon rude generalizations, obtained by a superficial and unphilosophical process of abstraction.

We shall not, at this time, attempt any discussion of these questions. We have faith in political economy as a science, and a perfect assurance that, whatever subdivision or specialization it may undergo, its vitality will remain unimpaired. We could, therefore, look upon the present contention with equanimity were it not for the reflection that, here in America, we are still disputing over those economical principles which in England are irrevocably settled.

However true the statements that the science has outlived its usefulness may be with regard to that nation, they have no application to the condition of the United States. Here its most fundamental propositions are matters for discussion and legislation, and the problems involved imperatively demand solution. We who, this year, are celebrating the hundredth anniversary, not of a book, but of the nation's birth, have still to decide whether the progress over which we are prone, rightly enough, to indulge in a good deal of self-glorification, has been helped or hindered by the policy of protection which has ruled hitherto; whether, had an opposite course been pursued, our internal resources might not have been quite as fully developed, and at the same time our external commerce have received a commensurate impetus instead of being at its present low ebb. This, and the condition of our currency, are very real questions with us; the way in which they are answered may make all the difference between continued progress and comparative immobility; and yet, while the country is in a ferment from shore to shore over the most inconsequential of elections, these important matters lie apparently dead in the public mind.

The profound stagnation of the commercial world has brought us nearly to a stand. Old combinations are disturbed and broken up. In the lull some of the hallucinations of speculative fever are disappearing, but the state of our finances is notoriously unsatisfactory, and that which Mr. Lowe is pleased to call the "great work" of political economy, the establishment of free-trade principles, with us remains undone. Is it not time seriously to consider what can be done to make the readjustment of the social elements a favorable one for us—one more adequate to the exigencies of the time?

Prolonged immunity from wars, the sway of sound commercial doctrines, the absence of the element of uncertainty in her finances, has enabled England to absorb a great part of the exchange business of the world. Continental disturbances made her opportunity, and she was ready to improve it. London is a vast clearing-house, while the United States do not act as middle-man between any two nations.

It is almost universally admitted that there can be no peaceful settlement of the Eastern question which can be lasting. Sooner or later it must be submitted to the arbitrament of war, and when that comes England cannot stand aloof. Engaged in such a struggle, she can no longer offer so secure a refuge as formerly to capital seeking a place of safety and stability. She must relinquish, in part at least, this function, and there is nothing mercenary in the suggestion that that would be our opportunity. But, however favorable for our aggrandizement foreign complications might become, they would now find us unprepared to take our rightful place in the world's commerce—unable to arrest the hour. Economical reform is an essential preliminary to success in such an endeavor. Our distance from Old-World centres finds compensation in our freedom from European entanglements; but the obstacles presented by a cumbrous and oppressive tariff, and a depreciated, fluctuating currency—compared with which three thousand miles of ocean are as nothing—would be simply insurmountable. And what is the prospect of their removal? The answer which must be given is not satisfactory.

There is reason to believe that the vagaries of inflationists are giving place to sounder financial views. There is warrant for the hope that the friends of free trade are increasing in numbers, and that its principles are slowly gaining ground, but no demonstration of this by legislation has yet appeared—nor are there any signs of it. Neither set of politicians seems to consider them worthy of consideration. Meantime the forces of protection are in close order, well appointed and alert—they will make a stout fight, and that there should, at this critical period, be a disaffection anywhere in the ranks of sound political economy, must be regarded as a matter of the gravest concern.

PROFESSOR MARTIN ON SCIENTIFIC EDUCATION.

LADY BURDETT COUTTS, who, having much money to give away, patronizes numerous charities and receives great applause, has come to be a kind of authority in the sphere of philanthropy, duty, ethics, etc. Hearing much said against science, on account of the experimental study of animals, she sought Prof. Tyndall, to inform him that science was growing *immoral*, because it did not formerly do such dreadful things as it is in the habit of doing now. Prof. Tyndall replied that it was rather growing *biological*, or passing into a new sphere to explore the laws of life, to which experimental investigations on organisms *in life* are indispensable.

This comparatively new subject, biology, which, after three centuries of preparation in physics and chemistry, has only been fully reached by the scientific mind of the world during the last fifty years, is now beginning to be recognized in its full import in our system of higher education. Biological chairs have been founded, and laboratories and schools of biological research have been established in connection with various of the old European universities; and although we, in this country, have had chairs, and schools, and museums of natural history, connected with our colleges, or apart from them, yet the provision made for biological study in the organization of the Johns Hopkins University at Baltimore marks a decisive step forward in the educational treatment of this important subject.

We give our readers the able inaugural address of Prof. Martin in entering upon his work at Baltimore, and they will be repaid by a careful perusal of it. The statement of principles, purposes, and plans, is excellent; and if they are carried out intelligently and perseveringly, as there is no reason to doubt they will be, the results cannot fail to be in a high degree advantageous. The proposed mode of combining original work with practical teaching is full of promise. Prof. Martin dispels the erroneous and injurious notion, too current, that original work means great discoveries. He points out how students of but ordinary capacity may yet do something to extend the boundaries of knowledge, while at the same time the important ends will be secured of mastering the true methods of inquiry, of making solid acquisitions, and of being able to teach from an actual understanding of the subject. What he says of the influence of scientific study, when conducted by proper methods, and in its genuine spirit, in cultivating the love of strict truth, and the mental habit of seeking it as the supreme thing, deserves the most serious attention. How to include a thorough discipline in truth-seeking, in our systems of education, is the problem of problems yet to be solved. No one who goes to church, or drops into the court-room, or visits our halls of legislation, or reads the newspapers, can fail to see that, with all their learning and volubility, our cultivated men are still very much in Pilate's state of mind in regard to truth. It may not be possible for all educated people to get the benefits of biological training as a part of culture, but the most salutary results will come from making scientific training an integral and established part of higher education. When thorough scientific culture once gets a fair foothold in our colleges and universities, so that its results can be compared with the purely literary training that now prevails, its influence will soon be felt, and we may safely leave the rival methods to the operation of natural selection. Meantime, our teachers will do well to consider carefully Prof. Martin's suggestions, and set themselves to the inquiry, how far it may be in their power to make application of them, in modified ways, in their own sphere of activity.

PROFESSOR HUXLEY ON THE HORSE.

We publish this month the third lecture of Prof. Huxley, as corrected by himself for The Popular Science Monthly, and accurately illustrated under the supervision of Prof. Marsh, of New Haven. The lecture deals mainly with the genealogy of the horse as traced far back into geological antiquity, by the discovery of successive fossil forms in successive strata or deposits. These forms are so closely related, and exhibit so graduated a series of modifications, as to establish the fact of a genetic and derivative relation from the lowest to the highest. The fossil terms of this series were already so far made out in Europe as to satisfy paleontologists there that the pedigree of the horse is established; but, by recent discoveries on this continent, the ancestral chain has been traced still farther back, so as greatly to strengthen the conclusion reached by foreign investigators. To the three ancestral forms found in Europe, which go back to what the geologists call the *Miocene*, Prof. Marsh had added two others, carrying the line back to the Eocene formations, and connecting the present Equus or horse-tribe with an early Eocene animal known as the *Orohippus*. In his lecture Prof. Huxley traced the relationship of these six ancestral forms of the existing horse, and based his argument for the demonstrative evidence of evolution on the continuity and extent of the series. But he went further, and stated what the characteristics of a still earlier form would be if it were ever discovered; and, within a month from his departure from the country, Prof. Marsh announces that fossils of the predicted animal have been actually found in the lowest Tertiary deposits of the West, giving the *Eohippus* as the seventh term of paleontological ancestry of the Equine group.

We pointed out last month that proof is a thing of degrees, and that demonstration may be cumulative; and the very case we were considering now furnishes further illustration of it. Prof. Huxley says that the doctrine of evolution and the Copérnican theory of the motions of the heavenly bodies have precisely the same basis, that is, "the coincidence of observed facts with theoretical requirements;" and that "an inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it." But the demonstration becomes still stronger when the requirements of theory lead to the prediction of what must follow from it, and Nature subsequently furnishes the facts that vindicate the prophecy. It is one of the highest tests of the truth of a theory, that it leads to new discoveries, as was conspicuously the case with the wave-theory of light. A scientific professor is reported to have said that the proof of the evolution theory is far less strong than that of the undulatory theory, while nobody regards *that* as demonstrated. On the contrary, it *is* so regarded, and with abundant reason. The objective existence of the ether may not be proved, but this conception is not essential to the theory, and is held by many as nothing more than a convenient assumption or hypothetical artifice to aid the imagination in picturing wave-actions. The essence of the theory, whether the medium assumed be ethereal or material, is that light originates in some kind of undulatory motion, and a rational optical science is now only possible on this view. In the sense in which Huxley uses the term demonstration, as "the coincidence of observed facts with theoretical requirements," it is an established demonstration, and evolution stands exactly on the same ground. The facts are what the theory requires them to be, and what it predicts them to be; it explains them by the operations of real causes, and offers the only explanation we can have without going outside of Nature to get it.

Prof. Huxley has done us great service by going over the question of evidence in his three lectures, and bringing out the full force of the proof for this doctrine, and to make any less claim than he has made is to be wanting in fidelity to the truth.

And from this point of view we must think that Prof. Martin, in his admirable introductory discourse, did not fairly represent the case in giving the scientific status of the principles of the conservation of energy and of natural selection. He said: "These ideas *may or may not* be true; increase of knowledge may confirm or may *possibly* upset them." So sharp an alternative as true or false, determinable only in a contingency of the future, certainly does injustice to the logical validity of these great ideas. They can no more be subverted or abandoned in the future than any other truths of experiment and observation. They may disappear by absorption into larger truths, may change aspects, but they are basal and permanent factors of science, and we see not why the professors of physics and mathematics might not open their courses by conceding the insecurity of the fundamental principles of their sciences with just as much propriety as the professor of biology.

COMMERCIAL MANIAS.

RECENT writers upon the subject of commercial manias usually indulge in congratulations over the fact that the world is grown more wise; that the mental aberrations of our day are less marked than those of earlier times; that, for example, the absurd Dutch tulip-mania, Law's wild Mississippi scheme in France, and the South-Sea bubble in England, find no parallel in these days of greater intelligence and self-control; that the time has gone by when a sharper could clear $10,000 in five hours by selling shares in "a company for carrying on an undertaking of great advantage, but nobody to know what it is!"

It is probably true that our tendencies are not quite so rabid as those of our fathers, but we hold on bravely to some of their worst follies. It was only at the last session of Congress that the advocates of an unlimited issue of irredeemable paper were strong enough to prevent any steps being taken toward resumption. It was but the other day that the progressive Commonwealth of Massachusetts chose as a representative B. F. Butler, who declares that the "progressive" dollar is a paper dollar so issued that it can never be redeemed. The absorbing interest of a presidential election has hushed somewhat the clamor for the interconvertible note scheme—which is to pay all debts, public and private, and make everybody easy without costing anybody anything—but, had all those who still fully sympathize with the financial imbecility of Mr. Peter Cooper voted for him, the old gentleman would have had a very different showing in the official count. Nor are there lacking concrete examples of credulity which rival any of the exhibitions of former generations. A case in point is now running its course in Spain.

A woman has opened a bank in Madrid for deposits in sums of a hundred dollars and upward, on which she pays interest as follows: twenty per cent. on receiving the deposit, twenty per cent. at the end of the first, second, and third months, and then at the expiration of the fourth month, when eighty per cent. has been already paid, she reimburses the entire sum lent. The payments thus far have been regularly made, and the public are flocking in crowds with their money, the deposits now amounting to several millions of francs. The bankers and savings-banks are being drained of their deposits by this extraordinary traffic. Hours before the bank opens in the morning hundreds of depositors collect, and the presence of the police is necessary to preserve order. In this case "nobody is to know" how the money is employed, and on that point contrary rumors prevail; some assert that the capital is used in working mines of fabulous wealth; others, that the woman is an agent of the Government, adding that it is thus procuring money on more advantageous terms than with its regular bankers! The true explanation will not be long withheld, unless the police interfere to prevent her running off with her plunder. This is almost a precise repetition of a case which took place in enlightened Germany four years ago—the Spitzeder affair of Munich. In this case enormous sums were confided to a woman banker, who lived in opulence, squandering the money of her depositors, and, as she could not repay them, she was sentenced to three years' imprisonment. Her time expired some months ago, and the likeness of the transactions at Madrid to her operations at Munich is strong enough to suggest a common origin.

These cases appear still more remarkable when we recall the fact that in Continental Europe the confidence in banks of deposit has never attained the strength that it has in this country and in England. Outside of strictly commercial circles and people of large means the practice of depositing money with a banker is comparatively unknown. Small dealers, mechanics, and farmers, still adhere, in the main, to the old custom of hoarding, in feather-beds or underground, that has descended from the troublous days of the middle ages. That men should go from the extreme of unfounded distrust of stable and well-managed institutions into the incredible folly of pouring their money like water into the tills of a barefaced swindler, would seem to show that the springs of human action have not been raised very much; that a love of great gains, a desire to get more than our money's worth, a credulous faith in the performance of impossible promises are still deeply rooted, and need but the stimulus of some new and untried humbug to develop an amazing number of credulous fools.

LITERARY NOTICES.

Knight's American Mechanical Dictionary. A Description of Tools, Instruments, Machines, Processes, and Engineering; History of Inventions; General Technological Vocabulary; and Digest of Mechanical Appliances in Science and the Arts. By Edward H. Knight, Civil and Mechanical Engineer. 3 vols. Pp. 2831; 7395 cuts. New York: Hurd & Houghton. Price (cloth), $8 per vol.

This comprehensive and valuable work belongs in the rank of the cyclopædias, although its author has seen fit to choose for it the less ambitious title of a dictionary. It is qualified as mechanical, and answers to this description, but mechanics goes deep and sweeps wide in the field of Nature and art. Indeed, philosophers are split into factions over the question how far mechanics actually extends in the economy of the world, some maintaining that even cerebral action in processes of thought is resolvable into mechanical elements and conditions. But, without going so far as this, it is indisputable that mechanical changes are extensively and profoundly involved in the ongoings of the material universe. It is a vulgar notion that the term mechanics is restricted to cog-work and belting, wheels, levers, and pulleys, and a glance at Mr. Knight's voluminous exposition of the present state of knowledge on mechanical subjects will quickly dispel the narrow notions that may have hitherto prevailed regarding it. As stated in his prospectus, "the work deals with the *mechanical side* of every subject that can be known or mentioned, and, as almost everything in the universe has a *mechanical side*, the work becomes encyclopedical."

Mr. Knight seems to be a man cut out for such an enterprise. He began it twenty-five years ago, and as the volumes, in their vast and accurate detail, abundantly show, he must have had an enthusiasm for the work that kept him at it with untiring patience and perseverance; but as mere industry, although a prime factor in the result, must have been insufficient unless acting in the most favorable circumstances, he went to the headquarters of opportunity in this country, the Patent-Office at Washington. He was here "engaged in the editing the Patent-Office Report" and classifying patents; and subsequently editing the *Official Gazette* and systematizing for examination the twenty thousand applications for patents which are yearly presented at the office. Sitting at the very centre and focus of the mechanical thought of the country, he had both the stimulus and the facilities for carrying out his long-cherished purpose, and the "Dictionary" no doubt owes its exhaustive completeness to the free command of facilities afforded by his position.

We know of nothing that more impressively illustrates both the great advance of knowledge in this sphere of science and art, and the great activity with which it is at present cultivated in all civilized countries, than a critical glance at the pages of this elaborate work. And its statements are so presented as to bring out this view most impressively. Mr. Knight has introduced a subsidiary feature of "special indexes," which is not only very useful to those who consult his work, but shows in a striking way the extent to which inventive construction has been carried in special lines of inquiry. For example, under the term "metre," we have a list of 218 instruments or machines for measurement, the description of each being found under its proper alphabetical heading. "These specific indexes afford the reader an excellent opportunity for investigating thoroughly all that pertains directly or indirectly to any special subject, by using the index under the title of that subject as a sort of head-centre, and following out its various branches through all their ramifications."

The work includes about 20,000 titles, and gives an exhaustive vocabulary of the technical terms that are employed in various trades and manufactures, and many of which are not to be found in the current large dictionaries. The work is, in fact, little less than a mechanical library, summarizing an endless multitude of books, and bringing up its accurate information to the present time. Of people who read and think at all, it is hard to think of any class that will not find it serviceable.

A COURSE OF ELEMENTARY PRACTICAL PHYSIOLOGY. By M. FOSTER, M. D., F. R. S., Fellow of, and Prælector in, Physiology in Trinity College, Cambridge. Assisted by J. N. LANGLEY, B. A., St. John's College, Cambridge. Macmillan & Co. Pp. 244. Price, $2.00.

As the sciences come to be more and more studied, directly and practically, there arises the necessity for books of special guidance in laboratory-work. In chemistry, treatises upon manipulation are as old as the science, and in recent years various works have been published, instructing the student in physical manipulations. The same necessity is now beginning to be felt in physiological study, and Prof. Foster's little hand-book now appears to supply this want for English-speaking students. The book has grown out of Dr. Foster's practice as a teacher. When in University College, London, he was in the habit of distributing among his students a syllabus to guide them in their work. This became extended, by the introduction of details, into a practical course, which is now published for general use wherever physiology is pursued, experimentally, or by the observation and verification of its facts.

Dr. Foster recognizes that the introduction of the microscope has given a direction to manipulative activity that is not altogether favorable to broad physiological study. The importance of histology is not questioned, but the tendency has been to pursue it separately, and to a certain extent to accept it as a substitute for physiological work on a large scale. Dr. Foster thinks that microscopical investigation can only be best pursued in combination with a full scheme of physiological work. He says: "Histological work, unless it be salted with the salt, either of physiological or of morphological ideas, is apt to degenerate into a learned trifling of the very worst description; and students are generally only too ready to spend far too much of their time in the fascinating drudgery of cutting sections and mounting stained specimens." And again: "The student who has mounted an exquisitely and beautifully stained section is only just so much the worse for his pains (as far as physiology is concerned) if he does not understand what the section means. Hence, when the features of some of the fundamental tissues and the general working of the more important mechanisms have been really learned, and the student has got, by doing things for himself, to know the value of a physiological experiment, and the pitfalls that are hidden under carmine and Canada balsam, he may be safely trusted to fill in the details of his study by means of reference to mounted specimens and to mere demonstrations, or even to descriptions of experiments."

Though the work is elementary, and is designed to be introductory to the author's "Hand-book for the Physiological Laboratory," it is, nevertheless, comprehensive, and covers the ground that should be passed over practically by every well-educated medical man. When our medical institutions provide better for this form of study, we can trust ourselves more safely in the hands of their graduates.

THE RELIGION OF EVOLUTION. By M. J. SAVAGE, Author of "Christianity the Science of Manhood." Boston: Lockwood, Brooks & Co. Pp. 253. Price, $1.50.

THE multiplication of works on the religious bearings of Evolution, against it and for it, attests the strong interest that is taken in this aspect of the doctrine, and, as interest is ever the first condition of active inquiry, this deep concern about the religious import of the theory is of great advantage, no matter what the basis may be. Probably nine-tenths of the opposition to the doctrine is theological in its inspiration and its form, there being no end to the books which have been issued during the last dozen years to prove that it is anti-religious and atheistic. But the discussion has already led to a reaction, or to a modification of extreme views; that is, it is admitted, even by those who rank themselves as opponents of the doctrine, that it is not *necessarily* either atheistic or irreligious. But these assaults upon Evolution have, moreover, called out defenses of it on the part of the religious, which have not only been useful in concentrating attention upon the subject, but have been very valuable in their liberalizing influence, and the light they have thrown upon the problem of religion itself.

To those who care for the religious aspects of the question, whether as involving the religious sentiments to which the doctrine is claimed to be favorable, or the influence it is exerting upon theological belief, the present work may be decisively commended. Its author is a liberal Unitarian clergyman, who took up the subject in a series of Sunday discourses, which were subsequently revised for publication in their present form. His treatment of the subject, which is entirely in its theological relations, is able and independent, and is presented in a clear, spirited, and eminently readable style. He aims to show that Evolution is not destructive of the religious sentiment; that it favors the most exalted conception of God; that it brings Nature into harmony with elevated religious feeling, and must be of great service to humanity in sweeping away many superstitions that have grown up in times of ignorance and become associated and deeply involved with religious emotions. Mr. Savage is at no pains to conceal the fact that he is not orthodox, and avails himself of many opportunities to hit his theological opponents, but he can hardly be expected to start new fashions in the pulpit, and the opportunity of position in the argument is too tempting to be resisted. There are numerous passages in this volume that we should be glad to quote, as where he treats of the practical character of the discussion, the immense influence on the thought of Christendom of the Mosaic cosmogony, and his chapter on the "Evolution of Conscience," but our space will not allow of quotations. We must refer the reader to the volume, which he will find fresh, piquant, and instructive.

PUBLIC LIBRARIES IN THE UNITED STATES OF AMERICA: Their History, Condition, and Management. Special Report. Department of the Interior: Bureau of Education. Part I. Washington: Government Printing-Office. Pp. 1187.

THIS huge volume, which is the exponent of the public reading in this country, is an extensive cyclopædia on the subject of libraries. The statistics which have been published annually by the United States Commissioner of Education have been too limited to satisfy an inquisitive public, which wanted to know everything relating to books, from the arrangements necessary for organization to the best manner of preventing the volumes from being soiled.

This centennial offering will give much gratifying information to the true American, showing him that a great advancement has been made in the intellectual as well as in the material resources of the country. Thus, in 1776, there were twenty-nine public libraries in the colonies, containing 45,623 volumes. Now there are reported to be 3,682 libraries, numbering from 12,000,000 to 15,000,000 volumes, including pamphlets. Started in connection with the district-schools in New York and Massachusetts, free public libraries in some form have been established in the majority of the States of the Union; and it is believed that in no other country do so many libraries publish catalogues and reports.

The report is occupied with giving, first, the history of public libraries in the United States; second, their present condition and extent; third, a discussion of the various questions pertaining to library economy and management; fourth, extended statistical information of all classes of public libraries. Subjects comparatively new are introduced, such, for example, as the advisability of establishing professorships of books and reading in connection with college libraries; or the beneficial results that would be produced by the employment of art-museums in free public libraries. The report has been well managed and is well arranged. The literature is especially good, as the greater part of the writing has been done by the various librarians throughout the country.

THE THEORY OF COLOR in its Relation to Art and Art-Industry. By Dr. WILHELM VON BEZOLD, Professor of Physics at the Royal Polytechnic School of Munich, and Member of the Royal Bavarian Academy of Sciences. Translated from the German by S. R. KOEHLER, with an Introductory Sketch by EDWARD C. PICKERING. Illustrated by Chromolithographic Plates and Woodcuts. Price, $5.

THE advantages of this work over others of a similar nature are derived from the fact that recognition is made of the recent progress in physiological optics. In the first part of the volume the theory of color is placed upon its proper basis in relation to science, showing the aid which the latter gives in the perception of colors, their system, and the law of mixtures. One of the leading features claimed for the book is its purpose to serve as a guide to the pictorial and decorative artist, giving him hints in regard to the color of leaves, of the sky, and of water; the use of Claude glasses; the effectiveness of small differences; the laws regulating the combination of colors, etc.

While the signature of the author is a good recommendation for the book, the names of Prof. Pickering and Mr. Koehler will greatly assist in the extension of its influence.

CHEMIA COARTATA; OR, THE KEY TO MODERN CHEMISTRY. By A. H. KOLLMEYER, A. M., M. D., Professor of Materia Medica and Therapeutics at the University of Bishop's College; Professor of Materia Medica and Pharmacy at the Montreal College of Pharmacy; and Late Professor of Chemistry, etc. Philadelphia: Lindsay & Blakiston. Pp. 111. Price, $2.25.

THE author has prepared this work "in the hope that it will prove useful to all who, from business occupation or from any other circumstance, may not have sufficient time at their disposal to consult the more voluminous works" which have been written. With the exception of brief introductory remarks to the different subjects, the book is composed of tables. The work is valuable merely from the convenience of referring to it, but could not be recommended to those who are beginning the study of chemistry, as there are many simpler and more comprehensive treatises on the subject.

NOTES ON BUILDING CONSTRUCTION. Arranged to meet the Requirements of the Syllabus of the Science and Art Department of the Committee of Council on Education, South Kensington. Part II. Commencement of Second Stage or Advanced Course. London, Oxford, and Cambridge: Rivingtons.

THIS second part is in no respect inferior to the first, and the interesting manner in which difficult subjects are discussed tends to fulfill the prediction that the different parts, when united, would make up a "body of principles on the subject of great value to practical men." Some of the subjects which appeared in the first part are here treated more minutely, and others of a more involved nature are introduced. Among the latter are "Centres," "Stairs," "Riveting," "Fireproof-Floors," "Painting," "Paper-hanging," and "Glazing." A third part is to follow soon, completing the work.

TWENTY-FIRST ANNUAL REPORT OF THE BOARD OF DIRECTORS OF THE ST. LOUIS PUBLIC SCHOOLS, FOR THE YEAR ENDING AUGUST 1, 1875.

FROM this report it appears that the number of pupils in the day-schools during 1874-'75' was 35,941; in the evening-schools, 5,751—showing a large increase in the latter. Of the day-school teachers, the males form but ten per cent. No discrimination is made in the salaries in favor of male teachers, and a competent woman, in the position of "supervising principal" obtains a salary of $2,200 per annum. The salaries distributed in the year reported amounted to $531,850. All departments of the public-school system are said to be in the most flourishing condition. In connection with the schools there is a public library which gives gratifying results of its usefulness.

Prehistoric Remains at Cincinnati. By Robert Clarke.

This is valuable as a memorandum of the prehistoric remains found on the site of the city of Cincinnati, which have already been obliterated, or are fast becoming so, by the extension of the city. It shows careful research. The main object of the pamphlet, however, is the vindication of the claims to importance of the "Cincinnati tablet" (engravings of which are given) found in a mound on Fifth Street, in 1841, by Mr. E. Gest. One face is sculptured, in low-relief, with hieroglyphics, which, from their singular resemblance to Egyptian carvings, excited much attention. It was accepted as genuine for thirty years, when doubt was thrown upon it by several writers, and since then it has been by many considered as a fraud. Mr. Clarke now brings forward a mass of direct evidence to show its genuine character as a true relic of the mound-builders, which it would seem hard to contradict; and adds that many who for a time believed the tablet an imposture are now convinced of its genuineness. No explanation of its significance or use, however, is attempted, except incidentally. Archæologists will be glad to read this paper.

The Greenstones of New Hampshire, and their Organic Remains. By George W. Hawes.

This is reprinted with a colored plate from the *American Journal of Science and Arts*. The greenstones referred to cover the upper end of the Connecticut Valley, and belong to the Huronian age, but the author considers them to have been formed from fine sedimentary deposits accumulated in still waters; that the metamorphic action under which they were consolidated was quiet or gentle in degree, far different from that which in the adjoining regions formed mountain-masses of granite and gneiss, and hence that their special location, in connection with the nature of the sediments, has determined the characters of the greenstone series. In certain of these rocks silicated remains of rhizopods and foraminifers are found, and Mr. Hawes figures some as seen under the microscope, with their natural colors. The pamphlet is an instructive one to geologists and mineralogists.

Filth-Diseases and their Prevention. By John Simon, M. D., F. R. C. S., Chief Medical Officer of the Privy Council, and of the Local Government Board of Great Britain. Printed under the Direction of the State Board of Health of Massachusetts. Boston: James Campbell. Pp. 96. Price, $1.

This book is well recommended by the Board of Health of Massachusetts, as it believes that, "if the practical suggestions made in it were acted on by all citizens, hundreds of lives now annually doomed to destruction would be saved, and the health and comfort of the people greatly increased." The work was originally published in England as a preface to a volume of excellent reports made by Government inspectors. The author first traces the characteristic diseases due to filth, such as diarrhœa, typhoid fever, cholera, etc.; next, the various forms under which filth operates; and, finally, the means to be taken to do away with its effects. He also discusses at some length the different closet-systems.

Fifty Years of my Life. By George Thomas, Earl of Albemarle. New York: Holt & Co. Pp. 420. Price, $2.50.

The Earl of Albemarle was born in the last year of the last century, and his recollections cover much interesting historical ground. The position of his family brought him in contact with royalty from his early youth, and many illustrious persons, civil and military, figure in these pages. The narrative is written in a gossipy and contented manner, characteristic of a man who has lived a long and enjoyable life.

Seventh Annual Report of the State Board of Health of Massachusetts.

This report is the careful compilation of an able committee, and the popularity which it has obtained is justly deserved. The authors emphasize the fact that "it is expedient to keep practical questions of sanitary law and work constantly before the people;" and they have accordingly presented the matter very forcibly. Such subjects as "Rivers Pollution" and "The Disposal of Sewage" are treated in their relations to disease. Aside from its local worth, the report is valuable on account of the general principles discussed.

The Davenport (Iowa) Academy of Sciences has sent us its first volume of "Proceedings," forming a neatly-printed book of 285 pages and 36 plates. Besides the records of meetings, catalogues of cabinet, etc., a large number of papers are included, which, although local in their nature, are yet of much general interest. Davenport is so situated as to afford many advantages to the student of Nature. The underlying limestone abounds in fossils of the Hamilton and Upper Helderberg groups; the rivers and ponds produce a remarkably fine development of molluscan life; while the close proximity of the prairies to the wooded bottom-lands affords a rich field for the botanist and the entomologist. This region was once the residence of a prehistoric people, who have left many obscure traces behind them, furnishing an abundance of material for the archæologist to ponder over. Among the essays are several reports of explorations of mounds at Albany, Illinois, and in the vicinity of Davenport, by Dr. R. J. Farquharson, and other archæological papers by C. Lindley, A. S. Tiffany, and J. D. Putnam; geological papers by W. H. Pratt; botanical matter by Dr. C. C. Parry, J. G. Haupt, and J. J. Nagel; lists of insects of Iowa and Utah, by J. D. Putnam; and studies upon land and fresh-water shells, by W. H. Pratt. This first volume is very creditable to the young Academy, and it is to be hoped a second similar publication may soon follow. We observe, by-the-way, that it is published "for the Academy by the Women's Centennial Association," and suggest that this would be an excellent way for our many societies of zealous women to spend their money in other cities than Davenport.

An Elementary Hand-book of Theoretical Mechanics, with One Hundred and Forty-five Diagrams. Pp. 146. Price 75 cents.—**An Elementary Hand-book of Applied Mechanics**, with Eighty-eight Diagrams. By **William Rossiter**, F. R. A. S., F. C. S., F. R. G. S. New York: Putnams.

These two volumes form a mean between the commonly-received elementary treatises on the subject and the more advanced works. While they are simple enough for easy comprehension, they contain many of the data necessary for an advanced student.

Henry Holt & Co. are just putting to press, in hope of having it ready by the end of the year, a "Classical Literature" by C. A. White, whose "Mythology" has been received with much favor. The book will contain biographical and critical notices of the leading writers in Sanskrit, Greek, and Latin, with specimens of their works, and some account of the relations of the languages.

PUBLICATIONS RECEIVED.

The Germ-Theory of Disease. By J. Maclagan, M. D. Pp. 266. London: Macmillan.

The Functions of the Brain. By D. Ferrier, M. D. Pp. 338. New York: Putnams. Price, $3.50.

The Carlyle Anthology. Selected by E. Barrett. Pp. 396. New York: Holt & Co. Price, $2.

David and Anna Matson. By Abigail Scott Duniway. Pp. 194. With Illustrations. New York: S. R. Wells & Co. Price, $2.

Octavius B. Frothingham and the New Faith. By E. C. Stedman. Pp. 50. New York: Putnams. Price, 75 cents.

An Alphabet in Finance. By Graham McAdam. Pp. 230. Same publishers. Price, $1.25.

Modern Physical Fatalism. By T. R. Birks. Pp. 311. London: Macmillan. Price, $2.25.

Geographical Surveys west of the One Hundredth Meridian (Wheeler). III. Pp. 681. With Plates. Washington: Government Printing-Office.

Chemistry Theoretical and Practical. Parts X. to XIV. Philadelphia: Lippincott & Co. Price, 50 cents each.

Proceedings of the Poughkeepsie Society of Natural Sciences. Vol. I., Part I., Pp. 150.

Prometheus. Weekly Magazine. Vol. I., No. 1. Pp. 28. New York: Charles P. Somerby. Price, $3 per year.

Proceedings of the American Chemical Society. Vol. I., No. 1. Pp. 80. New York: Trow & Co., printers.

Valedictory Address at the Indianapolis College of Medicine. By E. D. Foree, M. D. Pp. 19. Indianapolis: *Journal* print.

Report of the New York Meteorological Observatory. By D. Draper. Pp. 48. New York: *Evening Post* print.

Report of the Commissioner of Agriculture. Pp. 19. Washington: Government Printing-Office.

Field and Forest. Monthly. Vol. II., No. 5. Pp. 8. With Plate. Washington: The Columbia Press.

Mayer's Ontogeny and Phylogeny of Insects. *Also,* A Century's Progress in American Zoölogy. By A. S. Packard, Jr. Pp. 4 and 8.

Immediate Preparation and Early Resumption. By R. T. Paine, Jr. Pp. 31. Boston: A. Williams & Co.

A System of Marine Signals. By S. P. Griffin. Pp. 13. New York: Van Nostrand.

Appalachia. Organ of the Appalachian Mountain Club. Pp. 62. With Maps. Boston: A. Williams & Co.

Education and Progress: an Address by General T. M. Logan, of Virginia. Pp. 16.

Relations of Physical Health to Morality and Religion. By Rev. G. W. Cooke. From the *Herald of Health.* Pp. 8.

Death-Rate of each Sex in Michigan. By H. B. Baker, M. D. Pp. 16. Cambridge, Mass.: Riverside Press.

POPULAR MISCELLANY.

Deep-Sea Bottom Deposits.—The deep-sea bottom deposits found by the Challenger expedition are classified as follows by Mr. Murray, naturalist on the scientific staff:

1. Shore-deposits, and these are mud of a variety of colors, as blue, gray, green, red, also coral-mud and sands; 2. Globigerina ooze; 3. Radiolarian ooze; 4. Diatomaceous ooze; 5. Red and gray clays. To these may be added peroxide of manganese in nodules and grains widely diffused.

The character of the sea-bottom contiguous to the shores is determined largely by that of the adjacent lands. Thus coral-mud occurs in the vicinity of coral-islands, and volcanic products near volcanic districts.

This general feature of the coast extends in some cases 150 miles seaward; an exception was found, however, among the coral-islands of the Pacific, where the coral-mud occurs as a narrow band around the islands.

Globigerina ooze is the most abundant deep-sea deposit next to the clays. It does not occur in the inclosed seas in the Pacific north of latitude 10° north, nor south of latitude 50° south.

Radiolarians occur in most seas, but only in limited areas are they sufficiently abundant to give a distinctive character to the ooze. In the Antarctic Ocean a diatom ooze is found, and radiolarian ooze was brought up from the great depth of 4,475 fathoms—nearly four and three-quarter miles. The skeletons of these minute organisms are siliceous.

The red clay is the most abundant deposit, and below depths of 2,000 fathoms is very widely diffused. The skeletons of siliceous organisms are abundant in it, but calcareous shells are few, and in some specimens wholly wanting. The author seems to refer the origin of the red and gray clays to lavas, scoriæ, pumice, volcanic ashes, and possibly meteoric or cosmic dust; and adds, "If there be an ash after the carbonate of lime is removed by acid or other agent, this will be another source." But Prof. Wyville Thomson distinctly states that the red clay is essentially the insoluble ash or residue of calcareous organisms which form the globigerina ooze, after the calcareous matter has been removed; and this conclusion is confirmed by the very careful experiments made by Mr. Buchanan, who treated the ooze with dilute acids.

The author states that efforts to detect free protoplasm in the dredgings was attended by no definite result. Some specimens, however, assumed a jelly-like aspect, with flocculent matter when in spirits. This flocculent matter was found by Mr. Buchanan to be "sulphate of lime precipitated from sea-water, and the author infers that the so-called 'Bathybius' and the amorphous sulphate of lime are identical." In this connection he quotes a report on the subject by Mr. Buchanan which states that "the substance when analyzed consisted of sulphuric acid and lime, and, when dissolved in water and the solution allowed to evaporate, it crystallized in the well-known form of gypsum; the crystals being all alike, there being no amorphous matter among them." Mr. Murray's conclusion is that in "placing Bathybius among living things the describers of it committed an error."

Eccentricity in Wood-Growth.—Mr. T. S. Gold writes as follows, in the *Gardener's Monthly*, concerning the unequal deposition of wood in growing trees but partially exposed to the action of the wind: "A choke-cherry sprang from seed in front of my piazza, close to it, and could only be moved by the winds laterally. The section of the trunk was elliptical, the longer diameter being nearly double the shorter. Since the tree has grown above the roof of the piazza the trunk is becoming less elliptical. A young plum-tree standing close by the side of an out-building was killed by mice, and the sprouts were allowed to grow. These were all elliptical like the cherry, and made most wood on the two sides. It appeared to me that the trees made wood where it was most needed, on the sides where the strain of the wind came. Sometimes the eccentricity is produced by large branches or large roots on one side of the stem, and in other cases these seem to have little influence." This accords with the view of Mr. Herbert Spencer, who, in the appendix to his second volume of "Biology," gives the history of an interesting course of experiments "On Circulation and the Formation of Wood in Plants."

Notes on the British Arctic Expedition.—Of the two ships constituting the British Polar Expedition, the Discovery, Captain Stephenson, wintered at Cape Baird, latitude 81° 40′; and the Alert, Captain Nares, at Cape Union, latitude 82° 30′. The site of the supposed "Open Polar Sea" was found to be occupied by a rigid sea of ice, called the Paleocrystic Sea, or Sea of Ancient Ice. The thickness of this ice is enormous, varying from 80 to 120 feet. This Paleocrystic Sea is no doubt the accumulation of many years, or even of centuries. The lowest temperature experienced by the expedition was 104° Fahr. below freezing, which is 20° below the minimum observed by the Polaris Expedition. The sun was absent 142 days. A sled-party from the Alert planted the British flag in latitude 83° 20′ 26″; but, as they had to hew a track through the exceedingly rough surface of this frozen sea, seventy-two days were spent in accomplishing the journey. Another party explored the coast-line westward for a distance of 220 miles. The most northerly point of the coast of Grant Land was found by this party to be Cape Columbia—latitude 83° 7′, west longitude 70° 30′. The Greenland coast was explored by a party from the Discovery, and its most northerly point found to be in latitude 82° 50′, west longitude 43° 30′; thence the coast trends in a southeastern direction. A good seam of coal was discovered near the winter-quarters of the Discovery. A brass tablet with the following appropriate inscription was fixed on the grave of the gallant American explorer, Captain Charles Francis Hall: "Sacred to the memory of Captain C. F. Hall, of the U. S. ship Polaris, who sacrificed his life in the advancement of science on November 8, 1871. This tablet has been erected by the British Polar Expedition of 1875, who, following in his footsteps, have profited by his experience."

Sexual Selection among the Monkeys.—Mr. Darwin, in his "Descent of Man," holds that the brilliant coloring of the face in the male mandrill, and of the posterior callosities in that and sundry other species of monkeys, is the result of sexual selection. He now, in a communication to *Nature*, brings forward some new observations on this subject made by Joh. von Fischer, of Gotha. Von Fischer finds that not only the mandrill, but the drill and three other kinds of baboons, which he names, also *Cynopithecus niger*, *Macacus rhesus*, and *M. nemestrinus* turn the hind-parts of their bodies, which in all these species is more or less highly colored, toward him when they are pleased, and toward other persons as a kind of greeting. Many other facts of a like nature are mentioned by Mr. Darwin, and then he expresses the opinion that "the bright colors, whether on the face or hinder end, or, as in the mandrill, on both, serve as a sexual ornament and attraction. Any-how," he continues, "as we now know that monkeys have the habit of turning their hinder ends toward other monkeys, it ceases to be at all surprising that it should have been this part of their bodies that has been more or less decorated. The fact that it is only the monkeys thus characterized which, as far as at present known, act in this manner as a greeting toward other monkeys, renders it doubtful whether the habit was first acquired from some independent cause, and that afterward the parts in question were colored as a sexual ornament; or whether the coloring and habit of turning round were first acquired through variation and sexual selection, and that afterward the habit was retained as a sign of pleasure or as a greeting, through the principle of inherited association."

The Transmission of Habit.—A correspondent of *Nature*, resident in New Zealand, communicates to that journal several instances of the transmission of habits to offspring in animals. One instance is that of a mare which would wander away from the "mob" of horses to which she belonged —always seeking one particular creek. When released from work she would make off to her favorite feeding-ground by herself. One of her progeny some years after showed a similar liking for solitude. Again, a valuable mare was an incorrigible kicker; she transmitted her special vice to her offspring. Peculiarity in the form of the hoof has been transmitted to generation after generation. The same writer states that a particular strain of Dorking fowls which he has had in his possession for thirty years always show a restless desire for rambling, and this, too, under the difficulty of meeting with much persecution when straying beyond their range.

Efforts to stop the Locust-Plague.—In October a convention of the Governors of several Western States and Territories was held at Omaha, to devise means of withstanding the plague of locusts. Besides the Governors, there were present at the meeting a number of prominent farmers and scientific men. A memorial to Congress was adopted, setting forth the serious injury done to agriculture by the locust, and asking for the appointment of a commission to investigate the "history and haunts of this insect; also all possible means of its extermination, and remedial agencies which may be used against it." Prof. Riley, of St. Louis, delivered an address, in which he briefly narrated the habits and history of the Rocky Mountain locust. He considered that there were two main questions before the conference: 1. How best to deal with the young insects that threaten to hatch out over a vast extent of the country next spring; and, 2. The investigation of the insect in its native home, with a view of preventing its migrations into the country to the southeast. Prof. C. D. Wilber, of Nebraska, gave an account of the various means adopted in different parts of the West to counteract this plague. Governor Pillsbury, of Minnesota, gave a history of locust-ravages in various countries. Governor Pennington, of Dakota, offered a series of resolutions "respectfully but earnestly urging that all our people in the States and Territories afflicted by the locust-plague, of all denominations and sects, offer up special prayers in their respective churches for deliverance from this great enemy."

Insect Fertilization of Plants.—For a year Mr. Thomas Meehan has been making observations and experiments to determine whether insects are of material aid to plants in fertilization. His results, which are published in the *Penn Monthly*, appear to favor a decision of the question in the negative. That insects sometimes fertilize and cross-fertilize flowers, he admits, but he holds that these cases are less frequent than they are supposed to be, and that, when they do occur, they have no bearing on the general welfare of the race. The chief arguments for the necessity of insect fertilization, says Mr. Meehan, are drawn from structure and not from facts of observation. Thus it is stated that *Iris*, *Campanula*, dandelion, oxeye daisy, garden pea, *Lobelia*, clover, and many other plants, are so arranged that they cannot fertilize themselves without insect aid. But the author has inclosed flowers of all of these in fine gauze bags, and found that they produced seeds as well as other flowers that were exposed. And yet *Iris Virginica* and *Campanula* are common illustrations of the supposed necessity of insect fertilization. In one plant experimented with in this way (*Baptisia*), seeds were not formed. This plant, in the author's opinion, may possibly require insect agency for its fertilization. He does not deny that flowers are *sometimes* fertilized by the aid of insects; but he does not admit that this mode of fertilization is very common. His conclusions may be stated as follows: 1. That cross-fertilization by insect agency does not exist nearly to the extent claimed for it; 2. That, where it does exist, there is no evidence that it is of any material benefit to the race, but contrariwise; 3. That difficulties in self-fertilization result from physiological disturbances that have no relation to the general welfare of plants as species.

Proposed International Geological Congress.—A committee appointed by the American Association has issued a circular addressed to geologists, announcing the proposed convocation of an International Geological Congress, to be held at Paris some time during the Exposition of 1878. It is proposed to make the Congress an occasion for considering many disputed points in geology, and to this end it is desirable that the Geological Department of the Exhibition should embrace—1. Collections of crystalline rocks, both crystalline schists and massive or eruptive rocks, including the so-called contact-formations and the results of the local alteration of uncrystalline sediments by eruptive masses. In this connection are to be desired all examples of organic remains found in crystalline rocks, including Eozoon and related forms. These collections should, moreover, comprehend all rare and unusual rocks of special lithological, mineralogical, and chemical interest, examples of ore-deposits and of vein-stones of all kinds, with their incasing rocks. As far as possible these collections should be limited to specimens of a size convenient for examination, and be accompanied with sections prepared for microscopic study.

2. Collections illustrating the fauna and the flora of the Palæozoic and more recent periods, particularly of such horizons as present a more critical interest to paleontologists from the first appearance or the disappearance of important groups of organic forms. It has appeared to the committee that the organic remains of the Cambrian, Taconic, or so-called Primordial strata merit especial attention in this connection.

These various collections should be explained as fully as possible by labels, catalogues, monographs, and maps.

3. Collections of geological maps, and also of sections and models, especially such as serve to illustrate the laws of mountain-structure. In the geological maps, regard should be had to various questions which deserve the special consideration of the Congress, such as the scales best adapted for different purposes, the colors and symbols to be used, and the proper mode of representing superficial deposits conjointly with the underlying formations. The secretary of the committee is Dr. T. Sterry Hunt, of Boston.

Comparative Dietetic Value of Meat and Eggs.—A writer in the *Scientific Farmer* estimates the food-value of one pound of eggs as a producer of force, i. e., the amount of work the pound oxidized in the body is theoretically capable of producing, at 1,584 foot-tons, and the value of one pound of lean beef, from the same point of view, at 990 foot-tons. As a flesh-producer, one pound of eggs is about equal to one pound of beef, as is shown by the following analysis quoted by the author:

ONE POUND OF EGGS.

Water	12 oz., 86 grs.
Albumen	2 oz.
Extractive	130 grs.
Oil or fat	1 oz., 214 grs.
Ash	28 grs.

Will produce at the maximum 2 oz. of dry muscle or flesh.

ONE POUND OF BEEF.

Water	8 oz.
Fibrine and albumen	1 oz., 122 grs.
Gelatine	1 oz., 62 grs.
Fat	4 oz., 340 grs.
Mineral	350 grs.

The author hereupon remarks as follows:

"A hen may be calculated to consume 1 bushel of corn yearly, and to lay 12 dozen or 18 pounds of eggs. This is equivalent to saying that 3.1 pounds of corn will produce, when fed to this hen, 1 pound of eggs. A pound of pork, on the contrary, requires about 5¼ pounds of corn for its production. When eggs are 24 cents a dozen, and pork is 10 cents a pound, we have the bushel of corn fed producing $2.88 worth of eggs, and but $1.05 worth of pork.

"Judging from these facts, eggs must be economical in their production and in their eating, and especially fitted for the laboring-man in replacing meat."

Qualifications of Medical Students.—At the opening of the medical session of Glasgow University, last week, Prof. McCall Anderson said few could doubt that a preliminary examination of candidates for admission to the classes was called for, but if proof were required it might be found in the answers given to the following questions submitted to candidates by one of the examining boards: "What is meant by the antiquity of man?" Answer: "The wickedness of man." "The Letters of Junius?" "Letters written in the month of June." "The Crusades?" "A war against the Roman Catholics during the last century." "The first meridian?" "The first hour of the day." "To speak ironically?" "To speak about iron." "A Gordian knot?" "The arms of the Gordon family." "The Star-chamber?" "Place for viewing the stars." "To sit on the woolsack?" "To be seated on a sack of wool." "A solecism?" "A book on the sun." "The year of jubilee?" "Leap-year." They could, the professor added, have appreciated this last answer all the more heartily had it emanated from one of the female medical students. It is, however, only just on women to admit that they are, as a rule, serious in their studies, and are not in the habit of joking examiners. There is, indeed, an earnestness of purpose in their efforts to compete with man which entitles them to respect, and even imitation.—*Pall Mall Gazette.*

The Struggle for Existence.—Prof. Alfred Newton, in his address to the Biological Section of the British Association, described as follows the effects consequent upon the introduction by man of foreign species of animals into newly-discovered regions: "Set face to face with unlooked-for invaders, and forced into a contest with them from which there is no retreat, it is not in the least surprising that the natives should succumb. They have hitherto only had to struggle for existence with creatures of a like organization; and the issue of the conflict which has been going on for ages is that, adapted to the conditions under which they find themselves, they maintain their footing on grounds of equality among one another, and so for centuries they may have 'kept the noiseless tenor of their way.' Suddenly man interferes, and lets loose upon them an entirely new race of animals, which act and react in a thousand different fashions on their circumstances. It is not necessary that the new-comers should be predacious; they may be so far void of offense as to abstain from assaulting the aboriginal population; but they occupy the same haunts and consume the same food. The fruits, the herbage, and the other supplies that sufficed to support the ancient fauna, now have to furnish forage for the invaders as well. The new-comers are creatures whose organization has been prepared by and for combat throughout generations innumerable. Their ancestors have been elevated in the scale of being by the discipline of strife. Their descendants inherit the developed qualities that enabled those ancestors to win a hard-fought existence when the animals around them were no higher in grade than those among which the descendants are now thrown. The struggle is like one between an army of veterans and a population unused to warfare."

Economy in the Use of Steam.—A series of experiments has been made, as we learn from *Iron*, upon the 80-horse-power engine at Portsmouth dock-yard, for the purpose of testing the value of a process, the invention of Mr. Marchant, of London, whereby steam, after having done its work in the cylinder, is pumped back into the boiler, to be reutilized for steam-power. The advantage which the inventor claims for his invention is a considerable saving of fuel, because, inasmuch as it is economical to keep the boilers supplied with hot water from the condensers instead of cold water, it follows that to keep them supplied with steam direct from the cylinders must prove still more economical of fuel. The experiments appear to have been successful. The engine one day was worked as an ordinary condensing engine, when it was found that the consumption was 1,176 pounds of coal in six hours, producing an indicated horsepower of 84.747. The next day the engine was driven with Marchant's steam-pumps connected with the low-pressure cylinder; the consumption of coal was now 1,158 pounds, while the indicated horsepower was 104.123. The ascertained work on the steam-pumps was six indicated horsepower.

Gathering Rock-Crystals.—Searching for rock-crystals is one of the recognized industries of the Swiss Alps, and the men who follow this vocation are known as *Strahlers.* The following notes upon the search for these crystals we take from the *Moniteur Industriel Belge:* The outfit of a *Strahler* consists of a bar of iron four feet long and bent at one end, a shovel, a pickaxe, a hammer, a stout cord, and a leathern sack. Thus equipped, he goes out to his work in the morning. He nearly always goes alone, so as to have all he may find for himself. For hours and hours he creeps along the sides of the rock, on projections of a few inches, over yawning chasms. When he descries a vein of quartz, he strives to reach it, but oftentimes this is a matter of extreme peril, and involving much labor; he must be very careful where he steps, and not seldom he must hew out a resting-place for his foot in the rock. Having reached the vein, he follows it and strikes it with his hammer. His practised ear tells him whether he has to deal with a "cavern," a "druse," a "pocket," or a "kiln," as the various kinds of cavities are called in which are found the crystals—whether attached to the walls or loose and mixed with sand. The most famous discovery ever made of monster crystals is of very recent date. Some hundred feet above the snow-line an apothecary of Bern saw a vein of quartz 60 feet long and from 4 to 12 feet wide. On working the vein, four hundred-weight of crystals were taken out; the larger masses were purchased for museums, while the smaller pieces were sold to opticians.

NOTES.

The chemical laboratory for female students, in the new building adjoining the Massachusetts Technological Institute, has been thoroughly fitted up, and was occupied for the first time early in November.

Five specimens of ground coffee, chemically examined by C. H. Eddy, of Michigan University, were found to be adulterated to the extent of from 22 to 39 per cent. with chiccory. One package, labeled "Pure Mocha and Java," contained 23 per cent.; "Pure Rio," 25 per cent.; "Pure Java," 22 per cent.; "Royal Java," 31 per cent.; "Warranted pure government Java," 39 per cent. Besides chiccory, these prepared coffees consisted chiefly of peas, oats, starch, carrots, etc. In three of the five specimens no caffeine could be discovered.

White-lead, as a pigment, is chiefly valued for its "body," and for the ease with which it is laid on; but it produces lead-poisoning, and also tends to lose its whiteness. Zinc-white is not open to these objections. Properly prepared, it has as good covering properties as white-lead, and the addition of magnesia in the manufacture makes it as easy to work; besides, it has no injurious effects on the health of those who manufacture or use it.

An extensive deposit of plumbago has been discovered in Longswamp Township, Berks County, Pennsylvania. "The deposit," says the *American Manufacturer*, "is between seven and eight feet in depth, and the mineral is of the best quality. Similar deposits are supposed to exist elsewhere in the same region, and persons are now engaged in prospecting, but as yet no new discoveries have been made."

The *Library Table* for November contains a good sketch of the life and works of Mr. Darwin, with portrait. A valuable feature of this periodical is its classified index to current periodical literature.

The death is announced of the eminent French geologist, Charles Sainte-Claire Deville, at the age of sixty-two years. He was a native of the island of St. Thomas, graduated from the Paris School of Mines, studied the geology of the Antilles, and published the results of his investigations in 1856. Later he was Professor of Geology in the Collége de France. For many years he devoted himself to the study of meteorology, and to him in great measure is due the foundation of the Montsouris Meteorological Observatory.

No publications by professors or other *attachés* (*quœre:* officers, students, resident graduates?) of the Johns Hopkins University are permitted to be issued in the name of, or dated from, the university, without the consent of the professor to whose department the subject-matter belongs, or, in defect of such professor, of the head of the university.

The *Engineering and Mining Journal* proposes to its readers the following problem in proportion: If the German Continental Gas-Light Company is able to declare 13 per cent. dividends on its capital of nearly $3,000,000, when paying $5.75 per ton for its coal, and charging $1.01 and $1.35 per thousand feet for its 15.9 candle-gas, what are the profits of the New York gas companies, which pay $6 per ton for their coal, and charge $2.50 per thousand feet for a poorer gas?

In the School of Anthropology lately opened under the auspices of the Paris Faculty of Medicine, Prof. Paul Broca lectures on anatomical anthropology, M. F. Topinard on biological anthropology, M. Dally on ethnology, M. de Mortillet on prehistoric anthropology, and M. Hovelacque on linguistic anthropology. The course is open to the public.

Several members of the Paris Anthropological Society have promised each to write a will directing that his brain be sent to the society, for inspection and dissection. It is thought that, by procuring the thinking organ of persons whose habits and works are perfectly known, some light might be thrown on the laws of physico-mental organization. The scheme is anathematized by the leading religious newspaper of France, the *Univers*.

On and about pistons and journals which have been lubricated with animal and vegetable oils, lumps of dirty matter are found, consisting of iron oxide and fatty acids. Dr. Schöndorff has found that the oil is decomposed by steam into glycerine and fatty acid, and that the latter attacks the iron, causing enlargement of the cylinder. He therefore recommends the use of heavy mineral oils as lubricators.

An association has been formed and an estate purchased on the Sussex (England) coast, for building houses of a superior character, and on the most approved principles, so as to secure all the advantages depicted by Dr. Richardson as belonging to his "Hygeia," or City of Health.

The great maritime canal connecting Amsterdam with the German Ocean was opened November 1st, with imposing ceremony. The canal is sixteen miles in length, and has at the sea-end a harbor covering 250 acres, which, however, is not quite completed.

It is stated in *Land and Water*, as a fact beyond contradiction, that the choice English breeds of cattle have for some years not only tended to diminish in size, but also in robustness of constitution. The milk-yielding qualities of English cattle, too, are declining, so that the importation of cheese and butter is increasing enormously. This is strikingly the case with the Durhams, in which everything is sacrificed to form. In the finest strains of Durham cattle fecundity has been seriously affected, and the milk-secretion has become next to nothing.

The loss, in 1875, to Russia, from the ravages of wolves, amounted to about 15,000,000 rubles. The number of cattle killed was 179,000; of sheep, etc., 562,900. In the government of Kalouga alone the wolves killed 8,200 geese and 2,000 dogs. The human lives destroyed by the wolves are estimated at 200 per year.

At the fifth meeting of Russian naturalists, held at Warsaw, September 12th, proposals were favorably received to establish a zoölogical station on the Solovetzky Islands, and to request the aid of the Naval Department for dredgings in the Black Sea. Messrs. Grimm and Bogdanoff informed the meeting that they had undertaken two publications, a popular periodical, *Herald of Natural Science*, and a periodical in French or German, which would give to foreign readers brief notices of scientific work in Russia.

A miner at Nitshill, in Scotland, lately committed suicide by blowing himself up with dynamite. He procured a parcel of the explosive, went into the middle of the street, lighted the fuse, and leaned over the dynamite. The man was blown to atoms, and, on the spot where the dynamite had been laid, a hole was made about three feet deep by two and a half wide.

A commission appointed by the Government of Prussia to ascertain sundry anthropological data, has reported that of 4,127,776 pupils in schools, 42.97 per cent. had blue eyes, and 24.31 per cent. brown; 72 per cent. had blond hair, 26 per cent. brown, and 1.21 per cent. black. With regard to the color of the skin, only 6.53 had brunette complexion.

In a letter addressed to M. Dumas, of the Paris Academy of Sciences, M. Gachez asserts that vines may be protected from the ravages of the *Phylloxera* by planting "red maize" between the rows. The insect quits the vine and attacks the roots of the maize.

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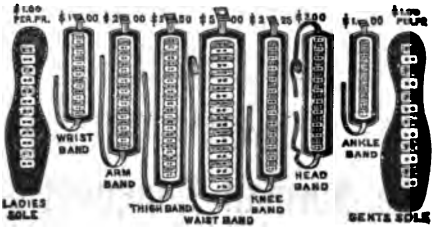

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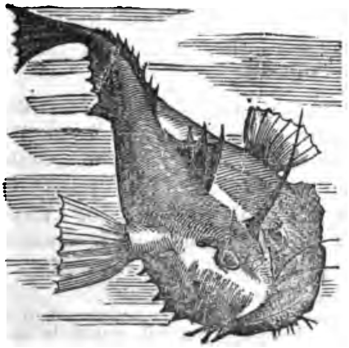

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